The N.P. Handbooks: No. 2

PRINT PERFECTION

How to attain it

By

DR. B. T. J. GLOVER, F.R.P.S

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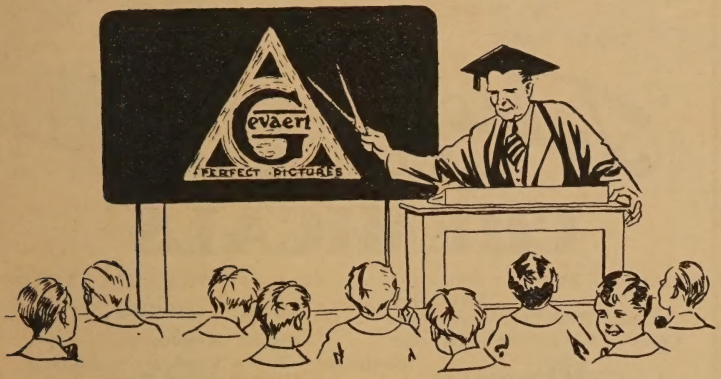

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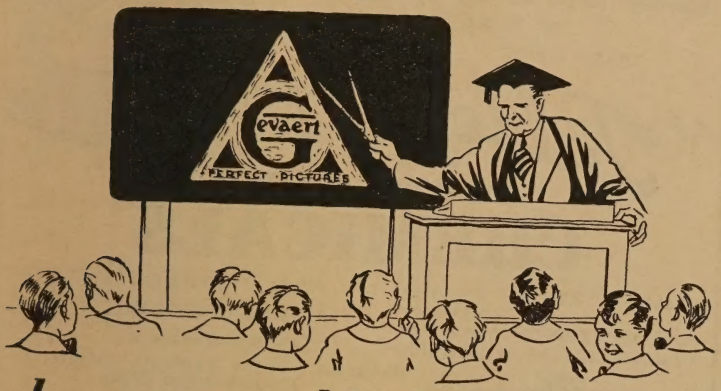

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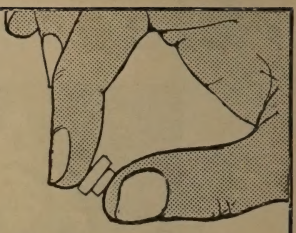

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By

DR. B. T. J. GLOVER

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PREFACE

The rules in this book which govern photographic printing are primarily designed to help beginners. They will prove equally helpful to others who experience printing difficulties.

Confident that printing by rule leads to the production of the highest possible print-quality with ease and certainty, the Author hopes that skilled photographers, whose printing difficulties have disappeared with experience, will try the working methods described.

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Chapter I.

INTRODUCTION

THE production of a satisfactory print requires the fulfilment of two conditions, namely :—

(*a*) The use of a suitable negative ;

(*b*) The proper exposure and development (or other treatment) of the printing paper.

The proper exposure and development of gaslight papers, bromide papers and chloro-bromide papers, and the practical working schemes relating thereto, will be the subject of this handbook.

The fitness or otherwise of a negative to yield a good print was fully discussed in *The N.P.* Handbook No. 1, * to which readers are referred. In this introductory chapter, however, it is proposed to summarise briefly some of the conclusions which were reached in that publication as to the means of conferring upon a negative the capacity to yield a good print, and the various ways in which printing papers differ from one another in their demands upon negatives.

A negative which has been truly under-exposed or truly over-exposed cannot be made to yield a perfect print by any known expedient. Such a negative has false tone values, and a print therefrom will possess tone values which are also false.

Given an appropriate exposure to the plate (or film), development is entirely for the purpose of making the negative fit in with the requirements of the printing paper. The arrival of a negative at a stage of contrast, during development, which is suitable for a specified printing paper, is purely a question of time. As development proceeds, the developing plate first reaches the

* " Perfect Negatives and how to make them," obtainable from any bookseller or from British Periodicals Ltd. 19, Cursitor Street, London, E.C.4, price 1/2 post free.

stage at which it is most suited for printing on a vigorous gaslight paper.This stage can be rendered permanent by removing the plate from the developer and fixing it in " hypo." If, however, development be prolonged for a further period, the negative passes beyond the stage wherein it is suitable for printing on vigorous gaslight paper and rapidly reaches one in which it requires a soft or normal gaslight paper to produce a good print. Again development can be terminated if the photographer so wishes. Further development produces a negative suitable for printing on bromide paper, and lastly, a little further development fits it for yielding good prints on chloro-bromide paper. Whether a correctly exposed negative has been properly developed or not depends entirely on whether the time of development has been rightly chosen for the particular printing paper upon which the photographer intends to print.

It is evident that a negative which has been developed for the wrong time for one printing paper may have been developed for the right time for another printing paper, and can be made to yield a good print if the right printing paper be chosen.

A print from a negative which has not been developed long enough to suit the paper is flat and lacking in contrast. * A print from a negative which has been developed too long to suit the paper is hard, exhibiting the " soot-and-whitewash " characteristics—as described in books.

Printing papers differ from one another so far as their printing capacity is concerned, merely in the length of time they require the negative to be developed in order to produce a good print. There is no difference between the tone rendering capacity of various types of paper. Each paper possesses white tones of equal whiteness and black tones of equal blackness. Each paper possesses the same capacity to render grey tones between

* Provided always that the flatness is not due to the faulty exposure and faulty development of the printing paper.

white and black. Provided that every paper is given a negative which suits it, prints on different papers are indistinguishable from one another. There is no best paper ; all are good, provided that they are given a proper chance of exhibiting their qualities by providing them with suitable negatives. It follows from this that one negative cannot be made to yield equally good prints on several varieties of paper. It also follows that it is an unfair test of a paper to compare a print on it with one on another paper, when both prints have been made from the *same* negative. If two papers differ in their printing characteristics, the one which shows up better under such a test is the one which happens to suit the negative.

With these brief introductory remarks in reference to matters dealt with more fully in the No. 1 Handbook, it is proposed to deal in the succeeding chapters with :—

(*a*) The properties of printing papers so far as exposure is concerned ;

(*b*) The reaction of printing papers to development ;

(*c*) The technical procedure appropriate to the practical work of print production.

Chapter II.

PROPERTIES OF PRINTING PAPERS

GASLIGHT papers, bromide papers, and chloro-bromide papers, collectively known as developing-out papers (D.O.P.), exhibit many similar properties so far as exposure is concerned. The fact that gaslight papers are slow papers, bromide papers are fast papers, and chloro-bromide papers constitute a printing medium of intermediate speed is a superficial difference of but little moment, requiring merely an adjustment of the strength of the printing light to obliterate it.

Every photographer knows that after exposure these papers exhibit no visible image, but possess a latent image which remains hidden until made visible by development. This latent image is in no way different from that produced on a plate (or film) when the latter is exposed in a camera. The part played by exposure in print making is identical with that played by exposure in negative making, namely, that it makes silver available for deposit by means of the chemical process known as development. The amount of silver capable of being deposited on the paper depends upon the exposure—the more exposure the more silver. Below a certain minimum exposure no silver can be produced on the print. On the other hand, at a certain maximum exposure all the available silver of the paper emulsion can be brought down by development, and no increase in exposure will yield more silver. In practical work a negative during the process of printing transmits various " exposures " to the printing paper in contact with it. Through the dense parts of the negative there passes very little printing light, so that, upon development, little or no silver appears on the print, a condition befitting the record of subject highlights and lighter

tones. Through the thin parts of the negative there passes abundant printing light productive of considerable silver on the print, recording in an appropriate manner subject shadow tones and other dark objects.

As in negative making, so in the production of prints upon developing-out papers, there are right and wrong exposures. It has been taught that a plate (or film) should be so exposed that all the subject tones are recorded in silver and that not even the darkest shadow tones of the subject should be recorded on the negative as merely clear glass (or celluloid) and gelatine. Expose for the shadows and leave the highlights to look after themselves is the rule in the exposure of plates. The exposure problem in printing is tackled preferably from a different angle. It is obvious that in the finished print it is usually required to depict the lightest tone of the subject as pure white paper. The subject tones, which are a shade darker, should then be represented as white paper darkened by a trace of silver, so that a very faint grey tone is produced. The photographer's attention during printing is directed preferably to the highlight end of the tone scale on the print, the end recording the action of printing light which passes through the densest deposits on the negative. In printing an exposure must be arrived at which just fails to record silver on the print in the very highest light, * and at the same time just succeeds in making available a faint veil of silver to represent any slightly darker tone. How about the shadow end of the scale of tones depicted by the print ? If the negative be a suitable one for printing on the printing paper chosen, it will look after itself perfectly well. The whole meaning of the teaching that the printing paper and the negative must fit and suit one another is that an exposure given during printing which will render highlights satisfactorily will at the same time yield a satisfactory rendering of shadows. If an appropriate printing exposure for the highlights fails to record the shadows properly, the paper and the

*There are exceptional subjects which can be deliberately printed in a low key.

negative are not suited to one another, and another paper must be sought if a satisfactory print is to be achieved.

In print making exposure is judged so that the highlights on the print are properly recorded when development is subsequently performed, and the shadows (on the print) are left to look after themselves, a procedure which tackles the exposure problem from the other end of the tone scale in comparison with negative making. And, as already remarked, if a satisfactory print fails to materialise from the proper application of this procedure, it is conclusive evidence that the wrong printing paper has been chosen for the particular negative from which the print is being made.

The highlight end of the print is chosen as the exposure testing end in printing, inasmuch as it is easier to detect the effects of under or over-exposure at that end of the tone scale in the print than it is to detect equal exposure errors at the shadow end. The effects of under and over-exposure will be described later, together with the practical method adopted in determining an approximate exposure.

There will be some who read who will consider that this question of the necessity of choosing a suitable paper to fit the negative in order to secure a perfect print is one which is being pressed with wearisome reiteration. It can be stated with confidence that there are many old hands at photography who have never given thought to it and who continue in consequence to use one printing paper because it is the best, so they think, and to throw away all negatives which do not yield good prints upon it, negatives, some of which, at any rate, would undoubtedly yield fine prints on other papers.

Exposure in printing is solely for the purpose of making silver available for deposit on development, and ts measure is that required to give a satisfactory rendering of the print highlights.

Development

When silver has been rendered available by appropriate exposure in printing it is the business of develop-

ment to make it visible. Whereas the development of a negative is an operation conducted for some period of time in order to make the negative fit the printing paper contemplated, the print is a finished product which stands revealed by its appearance and is not required to fit in with the requirements of any further photographic process. It is an end result which is right when it looks right.

After exposure, and for a short time after the application of developer, no visible image is apparent. At the expiration of a few moments the image appears—firstly the shadows, then the half-tones, and finally the high-lights, in the order of the measure of the exposure, a phenomenon no different from that exhibited by the appearance of tones on a developing negative. For what length of time must development be conducted ? It is obvious that there is a short time which must be exceeded inasmuch as it is necessary to wait for the image to appear and take form in all the print tones. Can development be carried too far, and if so how are we to know when to stop ?

A print upon a developing-out paper which has been made from a suitable negative can be considered perfect, so far as development is concerned, when the following requirements have been fulfilled :—

(*a*) The tones which should be black are the best black that the paper will yield ;

(*b*) The maximum contrast of the paper has been reached ;

(*c*) The half-tones on the print have assumed their proper position in the scale of tones.

It requires the use of apparatus and measuring devices to make sure not only that these characteristics of the finished print are a criterion of satisfactory development, but also that they have actually materialised, so that their enumeration is of no practical help to photographers who have neither a laboratory nor instrumental equipment at their disposal ; nevertheless, whatever system of print development be

adopted, it must enable these requirements to be fulfilled automatically if perfect prints are to accrue, even though suitable negatives be employed. Fortunately there are simple development rules which enable the photographer to ensure that his prints reach these standards, so that their adoption relieves him of any further cause for thought on this score. These development rules will be detailed later. In the meantime a few simple experiments can be described which will at any rate help those to whom these doctrines are novel to appreciate the necessity of printing by rule, and not as is commonly the case, in a manner dictated by fancy.

The three conditions *a*, *b*, and *c*, the fulfilment of which is necessary for the attainment of quality in a print, arrive at the time of their accomplishment during development at approximately the same moment. If a print be so developed that the best black procurable has been given time to materialise, then the print will have reached the maximum contrast possible and the half-tones will have settled in their proper places as depicted by the negative from which the print is made. Somewhat complex experiments and measurements of the results thereof have shown this to be true. Since it is possible for the ordinary photographer to follow the description of, and perform for himself if necessary, some of the experimental work which indicates the connection between the time of print development and the attainment of the best black tone of which the paper is capable, the paragraphs which follow will be devoted to this matter.

The Production of a Good Black Tone

The relationship between exposure and development and the production of a good black tone on a developing-out paper can be shown in the following manner. A piece of bromide paper is placed in a printing frame and exposed to a printing light without the intervention of a negative and a series of exposures is given so that one

will show, upon subsequent developmenet for a proper time, what exposure is required, under the conditions of the experiment, to yield a good black tone. Assume that 10 seconds' * exposure suffices and that the normal development time is 2 minutes. * To another piece of the same bromide paper an exposure of 10 seconds' duration is given and, after exposure, the paper is cut into six portions. Each of these portions is developed for a different time. Appropriate times with normal developer at 60°-65° F. would be 30 seconds, 50 seconds, 70 seconds, 100 seconds, 140 seconds and 200 seconds' development. At the expiration of the development time for each piece it is removed from the developer and plunged into a fixing solution (hypo). Upon comparison it will be found that the pieces of paper developed for 30 seconds, 50 seconds, 70 seconds, and quite possibly 100 seconds, will present a black tone which is less black, and hence less perfect, than that displayed by the blacks which result from 140 seconds and 200 seconds' development. In all probability there will be no difference between the two pieces of paper developed for the longest times, the maximum black, attained at about 140 seconds' development, exhibiting no increase as the result of further development. It would appear, therefore, that a time of development above some minimum time is necessary to arrive at a good black tone.

Amplify this experiment by a further one in which a time of development is employed which is less than that necessary to create a perfect black, and endeavour to compensate for the lack of development by giving (initially) more exposure. Under the same printing conditions as before, when 10 seconds' exposure sufficed, give to a sheet of bromide paper either 20 seconds, or 30 seconds or, or even 50 second's exposure, one which at all events is far greater than that required to produce a

* The exposure and development times mentioned in these paragraphs, although not far removed from average values met with in ordinary work are supposititious figures adopted for descriptive purposes only.

good black with normal development. Cut the piece of paper so exposed into six pieces and again develop each piece for a different time, namely, 30 seconds, 50 seconds, 70 seconds, 100 seconds, 140 seconds, and 200 seconds. It will be found upon comparison that nothing has been gained by means of the additional exposure—it still requires a development time of over 100 seconds to realise the best black tone.

From these two experiments it is concluded that :

(*a*) Development must be conducted for a period of time above a certain minimum or the full qualities of the paper, signalised by the attainment of the maximum black, fail to materialise ;

(*b*) A time of development below a certain minimum time cannot be compensated by any increase in exposure.

Similar conclusions can be arrived at in the case of gaslight paper and, with reservations, chloro-bromide paper.

Having decided that there is a minimum time of development below which a print fails to exhibit a proper quality, examine the position at the other extreme. Can a developing-out paper be over-developed ? What are the disabilities of developing for too long a time ? The limits to the prolongation of development are (*a*) the onset of fog and (*b*) the appearance of stain. Upon a finished print there should not be a vestige of either. A good paper will stand at least twice the minimum development necessary to ensure a good black, before fog or stain makes its appearance. It will transpire subsequently that the chief error into which the photographer is likely to fall is that of giving too little development to the print. Development rules will be given later, which will avoid this error or any danger of fog or stain through excessive development.

The maximum time of development permissible for a developing-out paper is that which is short of the onset of either fog or stain.

The contention that there is a minimum below which the time of development must not fall, and a maximum time beyond which it is not desirable to go, leads to the question as to what time of development between these extremes is to be considered correct. Is there more than one correct time of development within these limits? The answer is afforded by a very simple experiment. Assume that a certain bromide paper, under certain conditions of development, has a minimum development time of 2 minutes. Upon such a paper make a print from a suitable negative. Assume further that a printing exposure of 12 seconds was found to be one which, upon development for 2 minutes, yielded a satisfactory print. Let the effect now be tried of giving less exposure and more development. It will be found that there are several exposure-times of development relationships which will lead to identical prints. Trials will show that prints which result from 12 seconds' exposure and 2 minutes' development are identical with those resulting from 8 seconds' exposure and 3 minutes' development, and also those produced by 6 seconds' exposure and 4 minutes' development. More exposure than 12 seconds cannot be compensated by less development than 2 minutes, because the blacks suffer in quality as already described. Less exposure than 6 seconds cannot be compensated by more development than 4 minutes, because fog and stain arise and spoil the print. It is evident that with this particular bromide paper, and under these particular experimental conditions, any development time between 2 minutes and 4 minutes is correct provided that it is accompanied by an exposure which is appropriate for the time of development chosen.

This exposure-development relationship is such that the exposure and time of development are in inverse relationship to one another, their product being what mathematicians call a constant. In the example given 12 (seconds' exposure) $\times$ 2 (minutes' development) $=$ 24, and the product of 8 and 3, 6 and 4 is the same.

The same property is exhibited by gaslight paper, and also by chloro-bromide paper. * A vigorous gaslight paper developed with an appropriate developer at 65°F. will attain its maximum black in a development time of 20 seconds. It will resist fog and stain for about 40 seconds' development time. Over this range and for the attainment of identical prints, exposure is in inverse ratio to the time of development. An exposure of 10 seconds (through an appropriate negative) and development for 20 seconds, realises the same result as an exposure of 5 seconds (through the same negative) and 40 seconds' development. Once more the product of the exposure and the time of development yields the same figure.

This phenomenon is a very interesting one. It would appear that there is no ground for considering one time of development more appropriate or more correct than another time within certain strict limits. There is a range of correct development times, each one of which corresponds with a particular exposure. There is, within limits, a relationship between exposure and development, of such a nature, that a small exposure can be compensated by prolonged development and a long exposure compensated by short development, and the exercise of this power of compensation does not lead to loss of quality provided that the maximum development time is not exceeded and the minimum development time is passed.†

This give and take in the exposure and development of developing-out papers throws some light on the success with which some photographers guess what they are pleased to call the correct printing exposure. The best

* It will transpire subsequently that for the purpose of securing warm tones on chloro-bromide paper development is purposely conducted for a time less than a minimum time in the sense employed above and, under these circumstances, this exposure time-of-development relationship no longer holds good.

† The marked regression of inertia exhibited by developing-out papers when development is carried on after the attainment of the maximum contrast, which explains the exposure-time-of-development relationship described, is partly due to an excess of soluble bromide contained within the paper emulsion and partly due to the invariable practice of using a developer containing a soluble bromide.

that can be said is that practice has enabled them to make an estimate of the printing exposure required by a negative, with sufficient accuracy to be one which is included in the range of possible exposures already referred to, all of which have equal right to be regarded as correct. But guesswork leads to mistakes, and wretched prints which have had far too much exposure and much too little development are in common abundance.

It is, however, an interesting reflection that many to whom photography by rule is anathema, speak with unbecoming confidence of correct printing exposures, and even go so far as to claim an advantage from giving 10 per cent. more than a guessed normal so that control in development can be exercised, a refinement in guessing which is ludicrous in the light of the great latitude there is in exposure when compensatory development times are chosen.

And maybe it will now be apparent how meaningless is the common teaching that the development of a developing-out paper should be conducted to " finality." Presumably " finality " means that development is carried as far as it will go. If the experiment be tried of exposing half a dozen sheets of bromide paper, giving each the same exposure in contact with a suitable negative, and developing these exposures for 1, 2, 3, 4, 5, and 6 minutes respectively, the progressive darkening of each print, coincident with increased time of development, is an indication that long after the time that the print should be removed from the developer further development action is possible and will take place if allowed to do so. Development will cease undoubtedly in due course, but the stage at which it does so is preceded by the onset of fog and stain.

It has been suggested that the attainment of the best black tone is a criterion that a sufficient degree of development has been given. There are occasions upon which a scene is portrayed in which a black tone on the print is not required ; for example in prints in a high key which

are required to imitate a subject in a high key. Does this condition alter the time of development of the print? It has already been stated that a time of development necessary for the attainment of a good black tone is a time of development which is also necessary for the half-tones of a print to fall into their proper places. In a print made up of lighter tones only, all far removed from black, it is still necessary to employ the full development time to ensure that these lighter tones are in their proper places, that is to say, are true. A print consisting of highlights and half-tones only, is, as it were, a portion of print which contains highlights, half-tones, and deep shadows. But just as the highlights and half-tones of a print containing shadows enjoy development for the same length of time as that which is required to give the shadows the requisite blackness, so must a print containing highlights and half-tones only (a high-key print) be subjected to a time of development which would have been necessary to give black shadows their full blackness *had they been present.* It is destructive of the quality of highlight tones and half-tones to cut their development short of this minimum time.

The conditions which must be fulfilled in order that a satisfactory print from a suitable negative upon a developing-out paper shall result are as follows :—

(*a*) The time of development of the paper must be above a certain minimum time and below a certain maximum time the absolute measure of which depends upon the type of paper and the working conditions ;

(*b*) A correct printing exposure is one which yields a good print upon the completion of development for a time chosen between these extremes.

Chapter III

PRACTICAL METHODS—EXPOSURE

THE exposure required for the purpose of printing on any developing-out paper is influenced by the following factors :—

(*a*) The strength of the printing light and its spectral composition ;

(*b*) The distance from the light at which printing is conducted ;

(*c*) The opacity to light of the silver deposit in the negative and the colour of that silver deposit ;

(*d*) The speed of the printing paper ;

(*e*) The length of time for which the print is developed.

It may be stated at the outset that this formidable list of factors which have an influence upon the time of a printing exposure need cause no dismay to those who adopt a system of estimating exposure by means of a trial print. It will be shown in the paragraphs that follow that the making of a trial print is a very simple matter and leads in a sure way to the estimation of an appropriate exposure. If, however, the information derived from a trial print is to prove of service in the completion of a final print it is essential that the conditions under which the trial print is made shall be repeated exactly during the exposure and development of the final print. It is necessary, therefore, to give some consideration to the factors (*a*) to (*e*), which, by their variation (accidental or otherwise), can make the exposures given to a trial print unreliable as a guide to the successful completion of a final print.

The Strength of the Printing Light

All developing-out papers are sufficiently sensitive to light to allow of printing by the aid of artificial light. The common artificial light sources which are suitable are

paraffin oil lamps, gas jets (plain or incandescent), and electric filament lamps. Whichever light source is chosen, the important rule to remember is that the light must always be used at its best. It is misleading to make a trial exposure with the aid of light from a paraffin lamp or a gas flame in which the light is only half on, and then proceed to give the exposure, so ascertained, to a final print exposed to the same light source fully turned on. The simple way to make sure that the same strength of light is used for printing both a trial print and the final print is to use the printing light always so that it gives forth as bright a light as possible. To this end the lamp wicks should be turned up until a brighter flame no longer results from any further increase in flame area, and gas taps should be fully turned on. With an electric filament lamp the necessity for this precaution does not arise, inasmuch as no manipulation of the switch alters the strength of the light produced. It is as well to remember that gas pressure varies from hour to hour, and so does the voltage of a house electrical supply, so that fluctuations in the light value of " best " light from one time to another must be expected. It is rare, however, for a marked fluctuation to take place between the making of a trial print and the exposure of a final print, provided that these operations be performed within a short time of one another. Nevertheless it is possible that, if a trial print be made and the information as to the right printing exposure derived from it be noted for use in making a final print at a much later hour or even on another day, an unsuspected variation in the strength of the printing light may lead to disaster when making the final print.

The light source chosen for printing should be used at its best.

Printing Distance

By the expression " printing distance " is meant the distance which separates the printing frame, containing the negative and the printing paper, from the printing light.

Everyone knows that the nearer we approach a light the better lighting power it exhibits. Confronted with the problem of reading small print in a poorly-lighted room, we move nearer to the light so as to increase the illumination of the print and make it more visible. The nearer the printing frame is to the printing light the stronger is the illumination of the negative and the less is the time of exposure required for printing. If the printing light comes from a very small source, such as a small acetylene flame or the brilliant point of a piece of burning magnesium ribbon, there is a simple relationship between the light strength reaching the printing paper at different printing distances. Every time the printing distance is doubled the printing exposure is multiplied by four, the latter figure being the square of two, the multiple by which the distance is increased. Every time the printing distance is multiplied by three the printing exposure is multiplied by nine, again a figure which is the square of three, the multiple by which the distance of printing is increased. Conversely, if the printing distance is halved, the exposure will require to be cut down to a quarter of its previous value, a diminution of exposure calculated by squaring the alteration in distance. However, the exact relationship between exposure and various printing distances is of but little practical importance, since point light sources from which to print are rarely used. For light sources of comparatively large size, such as the large flat flame of an oil lamp, the large bright area yielded by a frosted electric bulb, or any light screened with ground glass, this law of inverse squares does not hold good, and all that can be safely said is that the further the printing frame is from the printing light the more exposure (in time) must be given. Nothing is lost by virtue of this state of affairs, since it is the intention to test the exposure by trial in a manner which will be described later, and to use the same printing distance for both the trial print and the final print. None the less the power to choose a printing distance has this importance,

namely, that a printing light which is too strong for a particular printing purpose—so that the time of exposure is inconveniently brief—can be made less powerful in its action, and therefore slower in the time of printing, by moving the printing frame further away from it. In like manner, weak printing light sources can have their printing power enhanced so as to yield exposures less inconveniently long, by approaching the printing frame nearer to the light.

In order that some guidance may be given to those who have had no experience of printing on developing-out papers by the aid of artificial light, and who have no idea at what printing distance from a chosen light their first attempt should be made, the following suggestions may prove helpful :—

Paper	Printing Light	A suitable Printing Distance for first trial.
Bromide paper	Ordinary gas burner (batswing)	2 feet
	Duplex paraffin lamp	2 ,,
	Incandescent gas burner	4 ,,
	Electric filament lamp, 16 c.p. ..	4 ,,
Chloro-bromide paper †	Ordinary gas burner (batswing)	1 foot*
	Duplex paraffin lamp	1 ,, *
	Incandescent gas burner ..	1 ,,
	Electric filament lamp, 32 c.p. ..	1½ feet
Gaslight paper	Ordinary gas burner (batswing)	1 foot*
	Duplex paraffin lamp	1 ,, *
	Incandescent gas burner	1 ,,
	Electric filament lamp, 64 c.p. ..	1 ,,

It must be remembered that these distances are merely suggestions for trial. Each type of printing paper is represented by many different makes which differ from one another in printing speed. The negatives of different workers, as well as different negatives of the same worker,

* It is not advisable to approach a ¼-plate printing frame within 1 foot of a printing light. The minimum printing distance for a ½-plate is 1½ feet, and for a 1/1-plate, 2 feet. Printing distances shorter than these give rise to uneven illumination of the negative. Somewhat prolonged exposures therefore are to be expected from the weaker light sources indicated by an asterisk.

† Chloro-bromide papers of different makes vary greatly in their speed.

differ from one another in their opacity to light and hence in their time of exposure requirements in printing. The aim should be to choose a printing light and a printing distance so that the exposure is neither inconveniently short—and hence difficult to time accurately—nor inconveniently long—and hence wearisome. A time of printing exposure which lies between 10 seconds and 1 minute* may be regarded as a convenient one.

It is obvious that whatever printing distance be chosen as appropriate for making a trial print the printing frame must be placed at exactly the same distance from the printing light when making the final print. It is useless to hold the printing frame in the hand at some guessed distance from the light. So held, the printing frame cannot be prevented from swaying nearer to and further away from the light during exposure, and it is wellnigh impossible to repeat with accuracy the same printing distance when exposing the final print, and avoid introducing irregularities in negative illumination which render any system of estimating exposure by trial farcical. Whatever printing distance be chosen for making a trial print, this distance must be accurately repeated when exposing the final print. The simple way to accomplish this is to place the printing frame firmly on the table squarely facing the printing light, mark the position it occupies by a chalk mark, or in some other way, and replace it in exactly the same position, guided by the mark, when the final print is being made.

A printing distance chosen for making a trial print must be repeated exactly when making the final print.

The Opacity of the Negative

Some negatives are thin and contain but little silver in their densest parts ; others are very opaque to light because they contain plenty of silver in every tone. Negatives which have had a generous exposure and have been developed for a proper length of time belong to the

* It is not implied that there is any harm in employing an exposure longer than 1 minute. With a weak printing light, an opaque negative, and a slow printing paper, an exposure of 3 or 4 minutes may be required, and if so, should be given.

latter category. It is obvious from the most cursory inspection that a thin negative is more transparent and allows more light to pass through it than is the case with an opaque negative. Printing exposures with opaque negatives will therefore be more prolonged than in the case of thin negatives when printed by the same printing light and at the same printing distance. Negatives also vary in the colour of the silver deposit, some being more or less a true black, others being brown or yellowish according to the nature of the negative developer and the manner in which it has been used. Brown or yellow negatives allow less *photographically* active light to pass through them than is the case with black (non-coloured) negatives, a difference in behaviour which again has an influence on the time of exposure required for printing. How do we overcome this difficulty, namely, that no two negatives are alike in their printing exposure requirements? By the simple expedient of making a trial exposure with the negative from which it is intended to make the final print. The information so obtained by actual trial is appropriate for use in the making of the final print.

Negatives differ from one another in the exposure which they require for printing, and the difficulties caused by these differences are overcome by arranging for trial exposures in the manner to be described subsequently.

The Speed of the Printing Paper

Bromide papers are comparatively fast and quick printing, gaslight papers are relatively slow and slow printing, * and chloro-bromide papers are of an intermediate printing speed. However, bromide papers vary considerably among themselves so far as their speed in printing is concerned, and so do the various makes of gaslight paper and chloro-bromide paper. Once again, the method of trial exposure before making the final print overcomes all difficulties. The trial exposures are made

* A gaslight paper may be from 500 to 1,000 times slower than a fast bromide paper.

on the paper it is intended to use for the final print. It can be assumed with a fair degree of truth that all the sheets of printing paper in the same package are of the same printing speed.

The Length of Time of Development

It has already been pointed out that the time of development can lie between two extremes—a short time which just allows the attainment of the best black of which the printing paper is capable, and a long time which just avoids print fog or stain. It has already been noted that, when the shortest allowable time of development is chosen, the exposure is about double that which is required when the longest time of development is employed. Suggestions will be made subsequently as to the time of development between these two extremes which is most fitting for practical work. It is sufficient to note here that, obviously, whatever time of development be chosen for developing the trial print, that time must be repeated exactly when developing the final print. It is useless to develop a trial print for one time and then expect the final print to fulfil expectations when it has been developed for a longer or shorter time.

The time of development given to the trial print must also be given to the final print.

It is evident that the system of estimating a printing exposure by trial before attempting to make a final print is not only dictated by the possible variations in the factors (*a*) to (*e*) given in an earlier paragraph, but is one which can make successful allowance for all possible combinations of these variables and, in one stroke, can solve the printing exposure problem. Those who guess a printing exposure, and who continue to do so in spite of advice to the contrary, flatter themselves that they can, instinctively, make allowance for all the factors which influence the time of printing. The print quality which results is not flattering to the accuracy with which the average " instinct " functions in this matter.

The simple conditions which must be fulfilled so that a trial print shall be a reliable guide to a final print can be summarised as follows :—

(*a*) Both the trial print and the final print must be made from the same negative, and on paper taken from the same packet.

(*b*) The strength of the printing light and the printing distance must be the same for both the trial print and the final print ;

(*c*) The development of both the trial print and the final print must be performed with the same kind of developer, under the same conditions, and for the same time.

It is now necessary to devise a scheme whereby a trial print can be so exposed that several exposures are included at the same time on the same piece of printing paper, one of which will declare itself more appropriate for use than the others.

How to Make a Trial Print

It is economical in both time and printing paper, when making a trial print on any developing-out paper, to include several different exposures upon the same sheet of printing paper, so that, upon development, the most appropriate exposure can be chosen and applied to the final print.

Let us make a trial print from a $\frac{1}{4}$-plate negative in contact with which, in a $\frac{1}{4}$-plate printing frame, is a sheet of any developing-out paper. * It is false economy to use a very small piece of printing paper for this purpose, and attempts to do so will lead to disappointment and failure. Upon this trial print it is desired to try the effect of five different exposures of which five seconds' exposure (let it be assumed) is the least to be included. What should the other four exposures be ?

It is a curious photographic law that if a series of exposures is required to show equal differences in the

* The fact that bromide papers and chloro-bromide papers require to be manipulated in a suitably lighted dark room, whereas gaslight papers can be made use of in a dimly-lighted ordinary room, is a matter which will be referred to later.

finished trial print, the exposures must be such a series as 5, 10, 20, 40 and 80 seconds, and not such a series as 5, 10, 15, 20 and 25 seconds. It will be noted that the first series of exposures shows each exposure to be double the one preceding it, whereas the second series of exposures consists of figures which increase by the addition of an equal number of seconds for each increase. This equal addition of seconds to each successive exposure does not lead to equal differences in the appearance of the various sections of the trial print. The correct series of exposures, namely, 5, 10, 20, 40 and 80 seconds, is chosen so that each successive exposure is twice as great as the one before it; any other multiple would serve a similar purpose, namely, yield prints exhibiting equal differences. Such a series of exposures as 8, 12, 18, 27 and 40 seconds is obtained by multiplying each exposure by $1\frac{1}{2}$. A series of exposures such as 2, 6, 18, 54 and 162 seconds is obtained by multiplying each exposure by three. However, an expanding series of exposures multiplied by $1\frac{1}{2}$ shows a difference between successive prints which, although equal, is too small, and an exposure multiple of three results in print differences which are too great for convenient working.

Having chosen 5 seconds' exposure as the least exposure worth trying on the trial print, it follows that the other four exposures for inclusion must be 10 seconds, 20 seconds, 40 seconds and 80 seconds respectively, a range of exposures so wide that it takes very little experience of printing to succeed, with but little chance of failure, in picking a range for trial which is practically certain to contain within it an exposure which is correct. The printing frame, containing the negative and the sensitive paper in contact with it, is placed on a chalk or other mark on a table squarely facing the printing light, and, whilst placing it there, the whole of the negative is protected from the printing light by covering it with a piece of opaque card large enough for the purpose. A watch is so

placed that seconds can be read easily. At a chosen moment the card is *completely* removed from before the negative with a rapid movement so that the full printing light illuminates the *whole* * of the negative. For five seconds the negative, and of course the printing paper beneath it, is thus exposed. At the expiration of five seconds the card is quickly replaced so as to cover up one-fifth of the negative only, leaving the other four-fifths still exposed to the full printing light. As soon as the watch shows that ten seconds have elapsed since exposure first started the card is pushed forward so that two-fifths of the negative is covered and the rest of the negative is still exposed. At the expiration of twenty seconds from the commencement of exposure a

* The simple way is to start exposure with the *whole negative uncovered* and then proceed to cover it up bit by bit. If the negative is completely covered at the commencement of exposure and is then *unocvered* little by little, difficulties arise when a proper series of exposure is given, namely, one in which each succeeding exposure rises by some multiple.

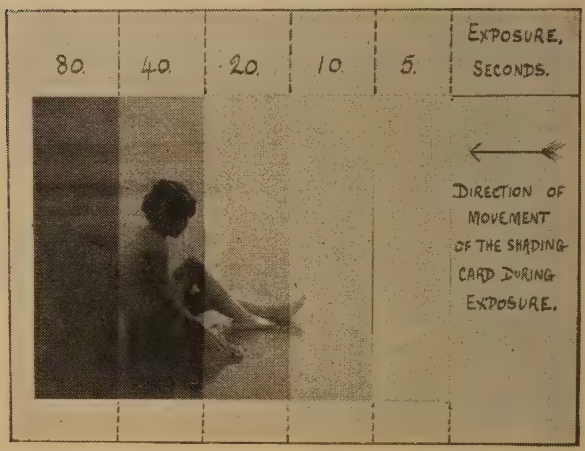

FIG. 1.

further forward movement of the card shades another fifth of the negative surface and leaves two-fifths of the negative still fully exposed to the printing light. Another forward movement of the card, at the expiration of forty seconds from the commencement of exposure, covers a further fifth of the negative, and the last fifth is allowed to remain uncovered until eighty seconds have passed, upon which event a final forward movement of the card completely covers up the whole negative. It suffices to keep an eye on the watch and, at the expiration of every exposure time chosen for inclusion on the trial print, to push the card forward so as to cover a portion of the negative, having commenced the exposure with the whole of the negative uncovered. It is obvious that by this simple procedure the printing paper has had 5, 10, 20, 40 and 80 seconds' exposure given to it in narrow strips, so that, upon development, the most appropriate of these exposures can be picked for repetition on the final print. Should it transpire that 80 seconds' exposure is insufficient, it is a simple matter to halve, or, if necessary, divide by four, the printing distance, thereby increasing the illumination of the negative, and make another trial print. If five seconds' exposure proves too much it is equally simple to double the printing distance, or even quadruple it, and again make a trial print. It requires very little experience to judge the printing distance from the printing light so that a correct exposure is somewhere between 5 and 80 seconds or any other equally dispersed range of exposures that the photographer may care to choose to suit his own working conditions, but it may take years of experience to guess the actual exposure required without a trial. A trial print which has been made in the manner described is reproduced in Fig. 1.

It sometimes happens that the correct exposure is one which lies between two of the exposures given to the trial print. It may appear that 10 seconds' exposure is too little and yet 20 seconds' exposure is too

much. In that event an exposure of intermediate duration, namely, 15 seconds, will be the correct one and will be appropriate for application to the final print.

It will be noticed that with every increase in printing exposure there has been an increase in the depth or darkness of the print. This is a universal phenomenon in photography, equally true of negatives and silver prints, namely, that exposure makes silver available for deposit by development, an increase in exposure leading to an increase in silver, to the limit of the silver contained in the emulsion. With this example, and with the proviso that the development of the print has been conducted for a proper length of time, * a fundamental truth in printing can be appreciated, namely, that a print which is too light is under-exposed, and one which is too dark is over-exposed.

In Fig. 1 the strip of the printing paper which had 20 seconds' exposure would probably be chosen as one the appearance of which is suitable for reproduction in the final print. It is certain that if 20 seconds' exposure be given to the final print, and if the precautions already described be taken to prevent an alteration in the printing light and printing distance, the whole of the final print will exhibit the depth and quality of the trial strip chosen for imitation. Fig. 2 is a final print in imitation of the 20-second trial print image.

Although it will be the purpose of the next chapter to state the rules for development and devise methods for carrying development to a proper conclusion, it is as well, at this stage, to call the attention of photographers to the importance of one essential condition attached to the development of a trial print, namely, that whatever length of time be chosen as the correct development time for the printing paper in use it is imperative that exactly the same time of development

* The rules bearing on the correct length of time of development will be dealt with in the next chapter.

be given to the trial print. An exposure chosen by an inspection of the trial print is of no value for application to the final print unless it is intended to develop both prints for the same length of time. It is possible to prevent an over-exposed portion of the trial print from becoming too dark by shortening the duration of the development. In that way lies total loss of quality, poor blacks, defective contrast, untrue tones, and sometimes a print of an unpleasant brown or green colour. It is also possible to force a portion of trial

Fig. 2.

print which is too light to become darker by prolonged development, but in that way lies fog and stain. It is disastrous to make any attempt to compel some section of the trial print to assume the right depth or darkness by any curtailment or prolongation of a suitable time of development chosen by rule. The

development of the trial print must be allowed to run its proper course whatever may be the appearance of the trial print resulting from this procedure. We are definitely setting out to find by trial what the various sections of the trial print will look like when they are developed for the correct length of time, and we are not concerned in the slightest degree with what they would look like if they were developed for an incorrect length of time. It is only by the faithful application of the correct development time to the trial print that the latter will yield true information as to the correct exposure. It may appear that undue emphasis is given to this matter, but it may be stated with confidence that the departure from the correct time of development for the trial print always results in a wrong exposure being chosen and is the common fault exhibited by those who fail to make prints of a good quality.

The rules which govern the calculation of the exposure required when printing on any developing-out paper may be summarised as follows :—

(1) Exposure is ascertained from a trial of several exposures included on the same sheet of printing paper ;

(2) The " trial " print so exposed must be developed for the length of time which is correct for the type of paper in use ;

(3) The correct exposure is that which produces on the trial print an image which is neither too light nor too dark ;

(4) This correct exposure, when applied to a final print in turn developed for the same length of time as the trial print, will produce the print required.

Photographers will find that as they gain experience there will be no need to make a trial print with so extended a range of exposure, such as from 5 to 80 seconds, in order to be sure to include upon the trial print an exposure which is appropriate. Having become familiar with the printing light, the printing distance, and the speed of the printing paper, and

having gained experience of the requirements of varied negatives, it is usually possible to give three exposures such as 5 seconds, 10 seconds, and 20 seconds, or some similar range such as 8 seconds, 16 seconds, and 32 seconds, and yet be sure of finding between the extreme exposures chosen one which will yield a good print.

Chapter IV.

PRACTICAL METHODS—DEVELOPMENT

REFERENCE has already been made to the fact that the three types of developing-out paper, namely, bromide paper, gaslight paper, and chloro-bromide paper, present similar properties so far as development is concerned. There is a minimum time of development below which it is harmful to go because by so doing the perfection of the black tones, etc, is sacrificed, and there is a maximum time which it is undesirable to exceed because to do so runs the risk of fog and stain. It has been stated that the maximum time allowable is approximately twice the minimum time in the case of papers of good quality coated with a clean working emulsion.

The factors, which by their variation, can influence the time of development are as follows :

(*a*) The nature, strength, and composition of the developing solution ;

(*b*) The temperature at which development is conducted ;

(*c*) The make of paper and the batch of paper.

It will be recognised that in no material way do they differ from some of those which influence the time of development of a negative. *

The Nature, Strength, and Composition of the Developer

Developing agents and developing mixtures suitable for developing paper prints are almost as numerous as those suitable for developing plates. Different developing agents yield silver deposits which differ slightly

* " The N.P." Handbooks, No. 1 (second edition), Chapter VI.

from one another in their colour—a matter of no moment in negative making, but of some importance in print making. A developing mixture containing metol and hydroquinone, and another one containing amidol, can be made to meet every requirement, and there is nothing to be gained by choosing another developer. Suitable formulæ for use in the development of bromide paper, gaslight paper, and chloro-bromide paper will be given later. In the meantime it is sufficient to note that a suitable formula, containing either metol-hydroquinone or amidol, having been chosen, there is no reason to vary its composition for any purpose whatever. Developer alterations lead to the loss of the one thing that we want to know about any developer, in print development as in negative development, namely, how long a time it takes in which to do its work. Photographers are therefore stongly advised to choose the developing mixtures given later, to apply the development rules that are given with them, and to rest content in the knowledge that there is little to be gained and much to be lost by altering them.

The Temperature of Development

The temperature at which development is conducted has a profound effect upon the time taken for a print to develop to a proper conclusion, just as it has upon the time of development of plates. It is very astonishing how little attention has been paid by photographers to this fact. For years it has been recognised that plates require different times of development at different temperatures, and innumerable time and temperature tables exist which purport to make due allowance and serve as a time guide to those who are not provided with apparatus which will enable them to develop at the same temperature on every occasion. One example will make it clear how profound is the effect of temperature upon the time taken by a bromide print to develop when the negative from which it is printed, the printing exposure, and the developing mixture

remained unvaried, and only the temperature of development is permitted to alter.

BROMIDE PAPER.

Temperature of Development	80° F.	68° F.	52° F.	40° F.
Time of Print Development	1¼ mins.	2 mins.	5¼ mins.	11¼ mins.
Result	Identical Prints.			

It is evident therefore that whatever scheme of development be adopted it must take into account the accelerating effect of a high temperature and the retarding effect of a low temperature.

The Make of Paper and the Batch of Paper

Papers of different make may develop at different rates. Papers of the same make may alter in the rate at which they develop from batch to batch (packet to packet). These differences are less pronounced than they are in the case of plates, but occasionally the writer has found them quite marked among bromide papers, although they are less marked and of no material importance in the case of gaslight papers. The system of development chosen must be able to make allowance for variations due to make of paper and batch of paper.

Such, briefly, is the development problem. What is the solution ?

The two schemes which meet the practical requirements of print making better than most others are as follows :—

(*a*) The development of all gaslight papers for a fixed time ;

(*b*) The development of all bromide papers and chlorobromide papers to a fixed Watkins factor.

The paragraphs that follow will be devoted to the consideration of the simple experimental evidence which has determined this choice.

The Development of Gaslight Papers for a Fixed Time

Gaslight papers, both vigorous and soft (or normal) varieties, when developed at a temperature between

65° F. and 68° F. with one of the strong developing mixtures recommended by all the gaslight paper-makers, exhibit extremely rapid development. Almost immediately after the developer comes into contact with the paper a properly exposed image flashes into sight, gains rapidly in depth, and within a very short space of time it is evident that development has made considerable progress. It can be shown by print measurements that under the conditions mentioned, namely, a temperature of 65° F. and a strong developing solution, the print can exhibit a maximum black tone, maximum contrast and tone truth throughout the scale, in the short space of 20 seconds. For practical working purposes this is the minimum development time. In an earlier chapter * it has been stated that double this time of development (associated with half the exposure) yields an identical print and yet is a time short of the onset of fog and stain. At 65° F. therefore it is possible to develop for any time from 20 seconds to 40 seconds and get identical prints when the exposure has been adjusted to the time of development. What do these times become at a much lower temperature, say, 55° F. ? † Trials show that the minimum time of development advances to about 30 seconds, and the maximum to about 60 seconds, the latter time of development necessitating only half the exposure appropriate for the former.

The following table is constructed as the result of actual trials with a vigorous gaslight paper developed with the metol-hydroquinone mixture given later.

	Temperature of Development 66° F.			Temperature of Development 55° F.		
	I.	II.	III.	IV.	V.	VI.
Exposure	12 sec.	8 sec.	6 sec.	12 sec.	8 sec.	6 sec.
Time of Print Development ...	20 sec.	30 sec.	40 sec.	30 sec.	45 sec.	60 sec.
Result	Identical Prints.					

* Chapter II, page 11.

† It is not advisable to develop gaslight paper at a temperature below 55° F., nor is it necessary to do so since the paper can be manipulated in an ordinary living room warmed by a fire in winter, provided that the room is but dimly lighted,

It is evident that if 30 seconds be chosen as the time of development on all occasions when the temperature of development is between 66° F. and 55° F.—a range of temperature which covers all practical requirements for the convenient manipulation of gaslight paper—it is possible to secure identical prints of perfect quality by adjusting the exposure. In summer, when the temperature is high (Col. II.), less printing exposure will be given than in winter (Col. IV.), when a room with a fire may possess a temperature so low as 55° F. On both occasions the actual exposure required is ascertained by trial in the manner already described. * Between the limits of 55° F. and 66° F. the effects of different temperatures upon the rate of development of gaslight paper can be compensated perfectly by adjusting the printing exposure. A suitable rule for developing all gaslight papers is that development must be conducted for exactly 30 seconds. Whether it is the development of a trial print or a final print makes no difference, the time rule given must not be departed from. There are, perhaps, a few occasions when the photographer must use the developer at a temperature lower than 55° F. The writer has made successful use of the M.-Q. mixture given later at as low a temperature as 48° F. For any temperature between 50° F. and 55° F. the time of development should be advanced to 45 seconds and for temperatures below 50° F. a further advance to 60 seconds is advisable. The development times chosen to meet these exceptional circumstances must also be applied to the trial print from which an appropriate exposure is being estimated. Every effort should be made, however, to develop at a temperature of 55° F. or higher if complete freedom from occasional trouble is to be secured.

The Development of Bromide and Chloro-Bromide Papers to a Fixed Watkins Factor.

The simple method of developing for a fixed time, applicable to gaslight paper, is not a suitable one for

* Chapter III.

bromide paper or chloro-bromide paper, for the following reasons :—

(*a*) Various makes of these papers vary considerably in the rate at which they develop, and hence in the total time required for complete development ;

(*b*) The effect on the time of development of alterations of temperature is very marked ;

(*c*) Few photographers possess heated dark rooms or apparatus for maintaining the developer at a higher temperature than the room, so that it is necessary to work at any temperature according to seasonal and daily fluctuations.

The special requirements of these papers, namely, that they must be manipulated in the light of a special dark-room lamp, makes it impossible to work them in an ordinary living room warmed by a fire.

It is claimed for the method of factorial development * —and the claim can be substantiated to a degree which, so far as developing-out papers are concerned, makes the system one of extraordinary convenience and considerable accuracy—that it makes proper allowance for the following possible causes of variation in the time of development, namely :—

(*a*) Alterations in the temperature of development ;

(*b*) Small variations (accidental or otherwise) in the composition of the developing mixture ;

(*c*) Differences that exist in the development peculiarities of one make of paper compared with another and in different batches (packets) of the same make.

What is factorial development ? Photographers are familiar with the fact that upon the application of developer to an exposed print a few moments of time elapse before the appearance of any image. The portion of the image on the print which does make an appearance before any other portion is that which represents the darkest part of the subject, the portion which, during printing, received the most exposure.

* Introduced by Mr. Alfred Watkins in 1894 as a method suitable for the development of plates and films.

Experimental work has shown that with each developer and developing mixture there is a definite relationship between the time which elapses between the application of the developer and the first appearance of any image on the one hand, and the total time required to complete development on the other.

In the case of an amidol developing mixture, which will be given later, the total time of development required by any make of bromide paper under any ordinary temperature conditions is ten times the length of time which elapses between the pouring on of the developer and the first sign of any visible image. With this particular developer it is necessary simply to time how long it takes for the image to appear, multiply that time by ten, develop for the total time so calculated, and, with certainty, there results a print which embodies the best qualities which the paper can yield out of the particular negative from which the print was made.

There are certain terms used in connection with factorial development. The time taken for the image to appear after the moment of application of the developer is called the time of first appearance of the image, occasionally contracted to the sign Ta for the sake of brevity. The figure by which Ta is to be multiplied in order to yield a total time of development is called the Watkins factor. * The total time of development is an expression which defines itself, and is, occasionally, designated by the sign Tt.

From the moment that a developer is poured over an exposed print until the moment that the print is removed therefrom and plunged into the " hypo " the developer is doing work. A certain amount of work goes to the proper completion of a particular print, and neither more nor less is appropriate. Some men may work more quickly on cold days than on hot days, but developers always work more slowly when the temperature is low than when it is high. The particular amidol developer,

* To be distinguished from the development factor, sign γ (gamma), another thing outside the scope of this Handbook

of which the Watkins factor is 10, accomplishes one-tenth of its work in making the image just visible. Obviously, therefore, it completes its work in ten times the length of time which it takes to make the image appear.* Anything which slows the accomplishment of the whole work also slows, to exactly the same degree, the accomplishment of the first tenth of it. A low temperature, which retards development, also retards the time of first appearance of the image. The length of time which the image takes to appear is a gauge of how quickly the developer is working under the actual conditions which exist during the development of the print.

An analogy may prove helpful. A journey is to be undertaken by motor-car. The distance to be covered is ten miles. It is assumed that once the car has started it will run at an even rate without disturbance until the end of the journey. How long will the journey take ? It is not known, because we have not been told at what rate the car will travel. Suppose that it were known before starting that at the end of the first mile of the journey there is a milestone, what then ? It is merely necessary to time how long it takes to reach this milestone and at once it can be calculated how long the whole journey will take. Three minutes to the first milestone and in 30 minutes time the whole journey will be completed. On another day it may be necessary to undertake the same journey in a different car, so that previous experience is of no value. How long will the journey take ? It will not be known until the first milestone is reached. It takes 2 minutes. The whole journey on this occasion will take 20 minutes. On different days there has been accomplished the same journey in different times, namely, 30 minutes and 20 minutes, and on each occasion advance information was obtained by timing how long was required to cover the first mile.

* This presentation of the case is not precisely true in terms of work done, but nevertheless is a picture or conception of some value to those to whom the factorial system is novel.

The development of a print is a journey accomplished in time. The first appearance of the image is a convenient first milestone, the time to reach which tells us unfailingly at what rate development is taking place. When circumstances are against the quick completion of development the same circumstances delay the arrival at the first development milestone, signified by the image becoming visible, and when development is rapid because of favourable circumstances an early appearance of the image is a measure thereof.

The Conditions of Successful Time Development

To be successful, the development of a paper print for a calculated time necessitates the fulfilment of two simple and readily attainable conditions, namely :—

(*a*) The maintenance of the same temperature throughout the whole course of development ;

(*b*) The use of fresh (unused) developer for every print.

The Maintenance of an Even Temperature

A time rule for development, whether it be a fixed time for gaslight paper or a variable time calculated factorially for bromide paper or chloro-bromide paper, is completely upset if the temperature at which development is conducted fluctuates during the course of development. It is useless to pour a warm developer over a print in a cold dish in a cold room, for if this is done there will be a steady fall in the temperature of development from one moment to another. As the temperature falls development becomes slower. To revert to the motor-car analogy, it is useless to time the car to the first milestone in order to be able to calculate the time that the whole journey will take unless it is certain that the car will run at a steady rate throughout. If, after the first milestone has been passed, a strong head wind arises which checks the car's progress, then assuredly the calculated time for the whole journey will prove to be false. The falling temperature of a warm developer is a steadily rising head wind against which development can only make ever-

slowing progress, retarded by an unknown and incalculable amount. How can the maintenance of an even temperature be ensured? When negatives are being developed various reasons make the use of a water bath necessary. In the case of prints, however, there is a more simple expedient, namely, that of developing at the same temperature as the room. For work which takes place in a dark room it is a simple matter to store therein a large jug of water so that a supply at room temperature is available, make use of dishes which have stood in the dark room and have therefore acquired the same temperature, and to refrain from warming either the developer or the dishes to a temperature above that of the room. Nothing could be more simple. If the developer be allowed to work at the steady room temperature, the factorial method of development will fulfil every requirement. The development of gaslight prints in a *warm* living room necessitates a supply of water and developer at the room temperature, a temperature condition which can only be fulfilled with the help of a thermometer. This is one of many purposes for which a thermometer is an indispensable tool to every photographer.

The systems of print development already described necessitate a steady temperature for their successful application, and the temperature of the work-room is the one that should be chosen.

The Use of Fresh Developer for Every Print

Photographers who set out to expose and develop a number of prints in succession are faced with two alternatives, namely :—

(*a*) To develop several prints in succession in the same portion of developer ;

(*b*) To use a small portion of unused developer for each print.

At first sight it would appear to be both economical and convenient to adopt the first method, whereas it is neither. If 20 small prints are passed in succession

through about 10 ounces of developer, the by-products of development alter the composition of the developer and slow its action. The twentieth print may require more than double the length of time given to the first print in order to reach the same degree of development and attain the good quality that development beyond a minimum degree ensures. Time rules cannot overcome developer irregularities of this description. Expedient (*b*) is the correct way of working—and is, moreover, not wasteful of developer. Half an ounce of one of the developing mixtures which follow is sufficient to develop a print of $\frac{1}{4}$-plate or any smaller size. One ounce of developer is sufficient for a $\frac{1}{2}$-plate print, 2 ounces for a whole-plate print, and one which is $15'' \times 12''$ requires 7 ounces of strong unused developer to ensure complete and quick development. These quantities are appropriate for use once only in conjunction with the size of print stipulated. This method is not wasteful. A greater number of prints than 20 cannot be passed through 10 ounces of developer without giving rise to trouble, apart from the difficulty in timing the development of the last few, yet the same 10 ounces of developer divided into 20 half-ounce lots can be made to develop 20 small prints one at a time. The great advantage that this procedure possesses is that fresh strong developer is used for every print and the time of development, indicated by rule, remains unaffected. There is no objection to the development of several prints at *the same time*, provided that sufficient developer is used and, after use, is discarded. Several prints developing together behave no differently from a large print developing by itself. It is the passage of prints *in succession* through the same developer which causes uncertainty as to the length of time that the last print in the procession should be developed.

In order to make a small quantity of developer cover a print evenly and quickly it is essential to soak the exposed paper in water before the developer is applied, so that not only does it cling to the bottom of the dish

without curling, but the wet surface will allow the developer to distribute itself over the whole area of the print without hesitation or delay. Obviously the water in which the print is soaked must be taken from the storage jug so that the print and the dish containing it do not suffer an alteration from the room temperature from which they will not have recovered when the developer is applied subsequently. Thin papers can be made thoroughly limp and wet by soaking for half-a-minute, but thick papers and postcards require 1 minute in which to absorb water evenly and completely. The soakage water must be drained away fairly completely before the application of the developer.

A Developer for Gaslight Paper

The following formula is one which is suitable for the development of any gaslight paper :—

METOL-HYDROQUINONE (Gaslight)

	English *	Metric
Metol	17 grains	2.0 grammes
Hydroquinone	50 ,,	6.0 ,,
Sodium sulphite (cryst.)..	1 ounce	50.0 ,,
[or Sodium sulphite (anhydrous) ..	½ ,,	25.0 ,,]
Sodium carbonate (cryst.)	12 drachms	81.0 ,,
[or Sodium carbonate (anhydrous) ..	265 grains	30.0 ,,]
10 per cent. solution of Potassium bromide ..	48 minims	5.0 c.cs.
Water to	20 ounces	1,000 ,,

The method of compounding it is as follows : Water to the amount of 2/5ths of the total quantity of developer to be made up (8 ounces or 400 c.cs. in the formula given) is placed in a clean glass vessel. Approximately † 1/5th of the total sodium sulphite is dissolved therein.

* The customary English practice has been followed in employing the avoirdupois ounce of 437½ grains and the apothecaries' drachm of 60 grains.

† It is sufficient to weigh *accurately* the whole of the sodium sulphite and divide it roughly into two portions, one of which is approximately one-fifth of the whole.

After solution is complete both the metol and the hydroquinone are added. To an equal quantity of water in another glass vessel is added the remainder of the sulphite, followed, after solution, by the sodium carbonate and the solution of potassium bromide. The latter mixture is now added to the metol-hydroquinone solution and, finally, water is added to bring the bulk to the total amount desired. Before mixing the two solutions it is important to be sure that all the ingredients are completely dissolved. Whilst compounding, both solutions should be kept as cool as possible. This developer has fairly good keeping qualities when stored in a well-corked bottle. The time of development for all gaslight papers with this developer *undiluted* is 30 seconds at temperatures above 55° F., 45 seconds at temperatures below 55° F. and above 50° F. and 60 seconds at temperatures below 50° F. when development at so low a temperature is unavoidable. *

It will be noted that it is suggested that all gaslight papers should be developed with this developer undiluted for the times given. Those photographers who wish to conform to the usual practice, namely, to use the undiluted developer for vigorous gaslight papers but to dilute it with an equal quantity of water when developing soft or normal gaslight papers, may do so if they wish. There is nothing to be gained by this dilution for soft papers. When diluted to half strength for soft papers the times of development already given should be doubled. *Under no circumstances should the developer be diluted before application to vigorous gaslight paper.*

The metol-hydroquinone formula given fulfils the conditions essential to a satisfactory developer for gaslight paper, namely, the possession of high energy and a richness in sodium carbonate. Other developing mixtures possessing these attributes are equally suitable.

* There should be no difficulty in avoiding the conduct of development at a temperature below 55° F. when a warm room is available. It is very undesirable to develop gaslight paper with this developer at a temperature lower than 50° F.

The white freak marks * so commonly seen on gaslight prints result from the use of a low-energy developer poor in sodium carbonate, particularly when the paper is slightly damp through being kept in an unsuitable place. A low temperature, by depressing the energy of the developer, may contribute to the same defect.

When compounding considerable quantities of developer, either for stock or for immediate use, there is no difficulty in measuring potassium bromide in the form of a 10 per cent. solution. On the other hand, if a small quantity of fresh developer is being made up for immediate use it is difficult to measure accurately the small amount of potassium bromide required. Photographers are advised to make up a 1 per cent. solution of potassium bromide for use on these occasions, so that the bulk of the liquid to be measured is an amount which admits of easy handling. A 10 per cent. solution for measurement in minims or c.cs. can be made by dissolving 48 grains of potassium bromide in water to make 1 fluid ounce† or 10 grammes in water to make 100 c.cs. This solution can be converted into a 1 per cent. solution by taking 1 ounce of the 10 per cent. solution and adding 9 ounces of water to make 10 ounces in all, or by taking 10 c.cs. of the 10 per cent. solution and adding water to make 100 c.cs. In the case of the 10 per cent. solution every 10 minims contains 1 grain of potassium bromide, and every 10 c.cs. contains 1 gramme of the same chemical. The 1 per cent. solution possesses 1 grain of potassium bromide in every 100 minims and 1 gramme in every 100 c.cs. It must not be forgotten that if on any occasion the 1 per cent. solution of potassium bromide is used in place of the 10 per cent. solution the quantity to be measured out of the former is ten times the volume appropriate to the latter.

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* White lines or patches where no image has developed.

† Or 1 ounce avoirdupois of potassium bromide in water to make 9 fluid ounces.

Developers for Bromide Paper

METOL-HYDROQUINONE (Bromide). Double Strength.

	English *	Metric
Metol	17 grains	2.0 grammes
Hydroquinone	70 „	8.0 „
Sodium sulphite (cryst.) ..	12 drachms	80.0 „
[or Sodium sulphite (anhydrous) ..	6 „	40.0 „]
Sodium carbonate (cryst.)	12 „	80.0 „
[or Sodium carbonate ..	265 grains	30.0 „]
10 per cent. solution of Potassium bromide ..	60 minims	6.0 c.cs.
Water to	20 ounces	1,000 „

For use dilute with an equal quantity of water,

This developer is compounded in a similar manner to that suggested for the M.-Q. developer for gaslight paper. It keeps fairly well in a well-corked bottle.

The Watkins factor for use with all bromide paper is 5.

An average bromide paper developed with this developer at 65° F. will exhibit a first appearance of the image in from 25 to 30 seconds, so that development will be complete in from 2 to 2½ minutes. The colour of image yielded is a fairly neutral black with a very slight suggestion of a warm black, a colour suitable for a paper with either a white or cream coloured base.

AMIDOL (Bromide).

	English†	Metric
Amidol	50 grains	6.0 grammes
Sodium sulphite (cryst.) ..	1 ounce	50.0 „
[or Sodium sulphite (anhydrous) ..	½ „	25.0 „]
10 per cent. solution of Potassium bromide ..	20 minims	2.0 c.cs.
Water to	20 ounces	1,000 „

* The drachms are apothecaries' drachms of 60 grains.

† In this formula the ounce by weight is the avoirdupois ounce of 437½ grains.

For use without dilution. This developer must be freshly made. It will not keep from one day to another, and, on occasions, it exhibits marked deterioration within a few hours' time. Photographers have occasionally been advised to make a stock solution of sodium sulphite in water and add amidol when required. This is bad practice. Some samples of sodium sulphite deteriorate very rapidly after solution in water, and in a very short time become valueless for any useful photographic purpose. This fine developer for bromide paper is useless unless it is quite fresh.

It is compounded in a simple manner. To the major portion of the water (18 ounces or 900 c.cs. in the example given) is added the whole of the sodium sulphite and the solution of potassium bromide. When the sulphite has dissolved, the amidol is added. It remains to add water to make up the bulk required. Amidol itself is a light grey powder when fresh and in good condition, but, unless it is kept in a tightly-corked bottle, it deteriorates fairly rapidly, loses its activity, and becomes very dark or even black in colour.

The Watkins factor for use with all bromide paper is 10.

An average bromide paper developed with this developer at 65° F. will exhibit a first appearance of the image in from 12 to 15 seconds, so that development will be complete in from 2 to $2\frac{1}{2}$ minutes. It has occasionally been written that an amidol developer gains in activity (ripens) when it has been allowed to stand for an hour or so after it has been made up. It appears to be inferred that this developer is an exception to the rule that from the moment that a developing agent is in solution, steady deterioration begins to take place. Amidol is no different in this respect from other agents, and deteriorates from the moment of solution more rapidly than most of them. The explanation of the increased activity on standing, although a simple one, is missed by those who compound this developer and use it without testing the temperature of the freshly-

made mixture. If water at the room temperature be used and sodium sulphite of the *crystalline* variety be dissolved in it, there is a fall of temperature of the solution of 4° or 5° F. Used at once (with the addition of amidol) such a cold developer acts more slowly than if it be allowed to stand for an hour and restore itself to the room temperature. It is quicker (and less mysterious) either to restore the mixed developer to the room temperature by warming it, or to employ in the first place water 4° or 5° F. warmer than the room in which to dissolve the crystalline sulphite. It is a feature of the anhydrous variety of sodium sulphite that, when passing into solution, it does not absorb heat and cause the drop in temperature referred to as characteristic of the solution of the crystalline variety. It is a matter of very great convenience, therefore, to use the anhydrous salt.

Amidol yields a silver deposit of a fine cold blue-black tone. For certain classes of subject the coldness of the colour makes it rather more suitable for papers with a white base than those with a cream base, particularly when a cream paper is being used to depict a warm sunlit scene.

The Watkins factors chosen, namely, 5 for the M.-Q. developer and 10 for the amidol developer, yield total times of development somewhat in excess of the minimum allowable time. A factor of 4 for M.-Q. and 8 for amidol gives a minimum time of development, and double these factors gives the maximum allowable time of development which, in conjunction with half the exposure, would produce similar prints.

It saves time to use a low factor since the process of development is slower in accomplishment than that of exposure.

Bromoil and Bromoil Transfer

Although it not the intention of the writer to make detailed reference to the technical requirements of the

bromoil process, it will not be out of place to devote a few paragraphs to the type of bromide print which lends itself most readily to inking, either for the purpose of a bromoil print or an ink print destined for transfer.

Those photographers who have some knowledge of the bromoil process know that the first stage consists in obtaining a suitable bromide print from a suitable negative. What are the characteristics of a suitable print ?

The basis of this ink printing process is that dry gelatine will take a greasy ink and wet gelatine will reject it. A tanned gelatine remains " dry " when soaked in water, and an untanned gelatine will readily absorb water and become wet. Gelatine which is partially tanned will absorb water to a lessened degree—a condition which allows it to be partly receptive and partly repellent of a greasy ink. It is possible, by employing a suitable tanning solution, * to affect a bromide print so that the portions of the print containing large deposits of silver are tanned strongly and hence made ink-receptive, the parts containing no silver are left untanned, and the remaining print areas possessing intermediate amounts of silver (half-tones) are tanned to an intermediate degree, conditions which favour varying degrees of wetness at a later stage in the proceedings resulting in areas more or less repellent of ink. It is of interest and importance to note that in the case of silver deposits in gelatine on paper over and above a certain blackness, differential tanning fails to take place —that is to say, if two black silver areas differ from one another in blackness (weight of silver), but both are above a certain limit, the tanning solution fails to tan these areas to a different degree of hardness, and thereby make their ink-receptibility different, but tans them both to the same degree so that ink takes equally freely on both, and tone differentiation is lost.† It is necessary,

* Popularly called the " bleaching " solution.

† Raymond E. Crowther, November, 1923.

therefore, to avoid on the bromide print the maximum black silver deposit of which it is capable, and also other black tones in the region of the maximum black. How is this done ? It has been pointed out already that if a piece of bromide paper is developed for a time short of some minimum time there is failure to obtain the best black of which the paper is capable. This expedient is the one commonly employed by bromoil workers to avoid silver deposits which are too heavy. It is bad practice. Any time of development less than the minimum which allows of the attainment of the best black tone, if that tone be present, is one which falsifies the half-tones and renders them inappropriate for yielding areas of gelatine appropriately tanned when exposed subsequently to the action of the tanning solution. There is another way of avoiding paper tones which are too black. It has already been pointed out that a negative which has been developed for a shorter time than normal for the printing paper in use yields a print which is flat. By this description is meant a print which exhibits a white tone at one end of the scale, but at the other end the darkest tone is not black but a very dark grey. It is possible to obtain a bromide print without any very black tones by printing from a negative which has been developed for a shorter time than that which makes the negative suitable for ordinary bromide printing and subsequently developing the bromide print normally. As the bromide print destined for bromoil is usually made by enlargement through a condenser lantern, such a negative destined for ink printing should be one which will yield a soft and well-graded contact print on a vigorous gaslight paper. * What is meant by a print which is exposed and developed normally ? The answer lies in what has already been taught, namely, a print in which the exposure has been ascertained by trial and development has been conducted to an appropriate Watkins factor.

* See " The N.P." Handbooks, No.1 (second edition), Chapter VI.

There is another point of importance. The tanning of the gelatine is the business of the tanning (bleaching) solution. No other solution used from the start to the finish of the making of a bromide print destined for inking should exert any tanning influence whatever, for assuredly if such a solution be used *general* tanning will take place as distinct from *differential* tanning and inking difficulties will arise subsequently. The great majority of developing agents in alkaline solution, or the products of their decomposition during development, are strong tanning agents.* Hydroquinone is a prominent offender. The oxidation product of development, quinone, can even be used in a ½ per cent. solution as a hardening agent for negatives, just as formaline is used for that purpose. A developer which is free from this hardening effect on gelatine is amidol. The formula already given is a suitable one.

The conditions which must be fulfilled in order that a bromide print may meet the requirements of bromoil or bromoil transfer can be summarised as follows :—

(*a*) The negative from which the print is made should be developed for a short time. A negative which yields a soft contact print on a vigorous gaslight paper is about right for enlargement by condenser lighting on to a soft-working (long scale) bromide paper ;

(*b*) The printing exposure should be such that when the paper is developed with amidol of the formula given to a Watkins factor of 10, a print is produced of which the highest light is white paper and the darkest shadow is less black than the blackest tone of which the paper is capable. This exposure is ascertained by trial in the manner already described.

* "The Tanning of Gelatine During Development": MM. Lumiere and Seyewetz, *British Journal of Photography*, April 13, 1906.

A Developer for Chloro-Bromide Paper

METOL-HYDROQUINONE (chloro-bromide).

Double Strength.

	English*	Metric
Metol	17 grains	2.0 grammes
Hydroquinone	70 ,,	8.0 ,,
Sodium Sulphite (cryst.)	1 ounce	50.0 ,,
[or Sodium Sulphite (anhydrous)	½ ,,	25.0 ,,]
Sodium Carbonate (cryst.)	1 ,,	50.0 ,,
[or Sodium Carbonate (anhydrous)	160 grains	18.0 ,,]
10% solution of Potassium Bromide ..	190 minims	20.0 c.cs.
Water to	20 ounces	1,000 c.cs.

For use dilute with an equal quantity of water.

The method of compounding this developer is similar to that already given in the case of the M.-Q. developer for gaslight paper. Its keeping qualities in a well-corked bottle are good, but, for the best performance, a freshly compounded developer is helpful.

The Watkins factor for the production of the normal warm black tone on chloro-bromide paper is 4.

A warmer black tone can be obtained by developing to a Watkins factor of 3, and a brown tone results when development is cut short to a Watkins factor of 2½.

It must be remembered that whatever Watkins factor be chosen, the trial print must also be developed to the same factor in order to ascertain the exposure required to yield a print of the required depth (darkness).

Whereas in the case of bromide paper the prints yielded by development either to a minimum or a maximum factor are not only identical in depth when the exposure has been properly adjusted to the degree of development, but are also of the same colour, in the case of chloro-bromide papers the colour of the image is influ-

* In this formula the ounces by weight are avoirdupois ounces of 437½ grains.

enced by the length of time of development, and can therefore be controlled by the Watkins factor to which development is carried, long exposure and short development (low factor) producing a warmer black image than that yielded by short exposure and long development (high factor). It is not desirable, however, to shorten development below a factor of $2\frac{1}{2}$, or poor tones and poor colours result, and there is nothing to be gained by prolonging development beyond a factor of 4. It will be remembered that there was a relationship between the exposure and the length of time of development in the case of bromide and gaslight papers, so that between a certain minimum and maximum time of development, prints of the same depth were produced when the exposure multiplied by the time of development, was a constant. This relationship breaks down in the case of chloro-bromide papers in the very shortened development times used in conjunction with the long exposures employed to produce warm colours. The folowing table gives examples of what can be expected in the exposure-development relationship in the case of two typical chloro-bromide papers :—

Temp. of Development 68° F.	Wellington B.B.		Kodura Etching Brown	
	Print I.	Print II.	Print III.	Print IV.
Exposure in seconds * ...	10	40	8	32
Time of appearance of image ...	40 seconds	28 seconds	45 seconds	30
Watkins Factor	4	$2\frac{1}{2}$	4	$2\frac{1}{2}$
Total time of development ...	160 seconds	70 seconds	180 seconds	75 seconds
Character of print	Normal warm black	Brown	Normal warm black	Brown

In both cases the shortest time of development (Watkins factor $2\frac{1}{2}$) requires about four times the exposure suitable for the long time of development (Watkins factor 4). In practice this relationship is of little importance, inasmuch as the exposure is ascertained from a trial print developed to the same Watkins factor as the one intended for use when developing the final print.

* Wellington B.B. is a faster paper than Kodura Etching Brown, so that in the case of the latter a more powerful printing light was used.

It is a matter of interest to note that the M.-Q. developing mixture given for a chloro-bromide paper is considerably weaker in alkali (sodium carbonate) than either of the developers given for gaslight paper or bromide paper. This low concentration of sodium carbonate serves to reduce the speed of development to one which is convenient, and also aids in the production of an image of fine grain. Images yielded by direct development which are coloured (warm blacks and browns) owe their colour to the fineness of the silver particles of which they consist, a colour effect due to the action of particles below a certain size upon the light with which they are illuminated when they are viewed. The finer the particles, the more towards yellow-brown does the image colour progress. Some workers advocate an M.-Q.-Borax mixture for this purpose, but its virtue is due to its low alkalinity, and the same effect can be obtained by the more simple expedient of reducing the amount of sodium carbonate in an ordinary M.-Q. mixture.

The correct printing exposures for various types of developing-out papers may be defined as follows :—

(*a*) The correct printing exposure for any gaslight paper is that which, when developed with an appropriate Metol-Hydroquinone developer for 30 seconds, yields a print which is neither too light nor too dark.

(*b*) The correct printing exposure for any bromide paper is that which, when developed with an appropriate Amidol developer to a Watkins' factor of 10, or an appropriate Metol-Hydroquinone developer to a Watkins' factor of 5, yields a print which is neither too light nor too dark.

(*c*) The correct printing exposure for any chloro-bromide paper is that which, when developed with an appropriate Metol-Hydroquinone developer to a Watkins' factor of $2\frac{1}{2}$, or 3 or 4, according to the colour of print desired, yields a print which is neither too light nor too dark.

Print Faults and their Remedies

Provided that print development has been carried out by rule as already suggested, the following table will enable the photographer to diagnose print faults and apply a proper remedy. It must be understood, however, that this table may be of no value to those who develop by inspection and, by so doing, run the risk of errors due to faulty development. The table is only true of prints which have been correctly developed.

Fault	Cause	Remedy
The print is too light	Under Exposure	Give more exposure
The print is too dark	Over-exposure	Give less exposure
The print is flat and lacks contrast	The negative has not been developed long enough for the requirements of the printing paper	Try a print on another paper which gives greater contrast or intensify the negative *
The print is too hard, possessing contrasts which are too great	The negative has been developed too long for the requirements of the printing paper	Try a print on another paper which gives less contrast or reduce the negative *

Reduced to rule, printing on developing-out papers is not only a very simple and certain business, but visible faults can be attributed without fail to their proper cause.

A prolonged experience of the printing troubles of others has convinced the writer that the *over*-exposure and *under*-development of all varieties of developing-out paper is the most common cause of failure. It is particularly so in printing on bromide paper, because this printing medium is extremely sensitive to light, requiring but brief exposure to a comparatively weak printing light, and is slow to develop. Any degree of over-exposure prevents development being carried to its proper conclusion because, in the process, the print will become too dark or even completely black. The photographer who does not work to rule endeavours to prevent the print from growing too dark by snatching it out of the developer at an early stage of development.

* "The N.P." Handbooks, No. 1 (second edition), Chapter VIII.

Once the fact is grasped that a print which gets too dark when a full time of development is given, is an over-exposed print, real progress in good printing will be made. The simple plan is to make sure that development is correct by adopting and carrying out a development rule, and the exposure can then be adjusted to fit in with development. With that principle before them, photographers will find that it is wellnigh impossible to go wrong.

Objections to Factorial Development

An experience of several years' duration in teaching factorial methods of print development has enabled the writer to learn the objections to this method raised by those who, accustomed to expose and develop prints in a haphazard manner, and encouraged to do so by most of the current teaching on the subject, are extremely critical of mechanical methods of printing, even though they are prepared to accept similar methods for the production of negatives. It is a curious trait, common in photographers, that the introduction of a system tends to rouse the critical faculties to a high degree, and comparatively minute errors and incompatibilities are magnified out of all proportion to their real importance. Errors in exposure and errors in the time of development when the latter operation is conducted by inspection alone, may, and frequently do, reach a considerable magnitude and yet remain hidden except to those who detect their effect in the finished product. Nevertheless, errors of 10 per cent. or so which can creep into factorial developments, of which the effect cannot be detected in spite of the most critical examination of the print, excite the condemnation of those upon whom any rule in photography has the effect of a red rag on an angry bull. It has taken 33 years for some photographers to recognise that the principles first enunciated by Messrs. Hurter and Driffield are true, and that the time development of negatives is sound in practice, and there are still

many who refuse to believe it. Print-making is even more subservient to rule than negative-making, and it is devoutly to be hoped that the recognition of the fact will not be postponed until another 30 years have passed. The printing characteristics of various printing papers are fixed by the paper-makers, and admit of no useful modification by the photographer. All we can do in printing is to obey the rules and make normal use of the printing materials at our disposal.

Two commonly raised objections to factorial development are as follows :—

(*a*) An error in the timing of the first appearance of the image leads to an error in the total time of development.

(*b*) The development of a trial print factorially leads to the time of first appearance of an over-exposed portion of the print being taken as the basis of calculation, resulting in a total development time which is too short.

It can be admitted at once that errors can arise in both these ways. Are they likely to be large enough to matter ?

It is necessary, in the first place, to get hold of the idea that an error is of no moment unless it is great enough to give rise to a falling off in the full perfection of the finished print. The owner of a garage just wide enough to accommodate a touring car, has to exercise care in the purchase of a large car lest, when purchased, *it* is found to be too wide or too long for its accommodation. An inch or two one way or the other may make all the difference between success and failure. The allowable error is small, and any error above a small one leads to disaster. The owner of a similar garage can, however, purchase a small two-seater with a care-free mind, conscious that there is abundance of room and that a foot one way or the other in the width or length of the car is of no moment. The permissible error is large, and only gross errors are disastrous. The task of developing a developing-out paper is

analogous to that of fitting a small car into a large garage ; there is room for mistakes, or deviations from a mean path without disaster.

What is the measure of a probable error in timing the first appearance of the image ? Accuracy is favoured by the following conditions :—

(*a*) A good light in which to watch the print.
(*b*) A satisfactory method of counting seconds.
(*c*) A time of appearance which is neither so rapid that it is difficult to time easily, nor so long that there is a doubt as to the exact moment at which the image appears.

There is no difficulty in arranging for a good inspection light so that the appearance of a *black* image against a white or cream background can be detected at once. There is no difficulty in timing with the aid of a watch possessing a seconds hand, and, if timing is done by sound in the simple way which will be indicated later, there is very small chance of an error of importance. Nor are the times of first appearance of the image already detailed in the paragraphs above either below the minimum time which makes accurate timing difficult, or above the maximum time which makes it doubtful. It can be stated with confidence, that an error of 10% in timing the first appearance of the image is the most that need be feared and, on most occasions, and with the aid of a little practice, the error will be very much smaller. Such an error is about $1\frac{1}{2}$ seconds when developing a bromide paper with amidol at 65° F., leading to a 15-second error in a total development time of 150 seconds. The difference between two prints, one of which has been developed for 150 seconds and the other for 135 seconds at this temperature is negligible. The same remarks apply to errors in timing the first appearance of the image with the M.-Q. developer mixture given. There is no need to fear any serious error in the total time of development due to mistakes in timing how long it takes the image to appear.

How about the second objection (*b*), namely, that a wrong time of first appearance results when the over-exposed portion of the trial print is being watched. It has already been suggested that if it is estimated that 20 seconds' printing exposure is somewhere near the mark, a trial strip possessing exposures of 5, 10, 20, 40 and 80 seconds is appropriate. Let it be assumed that the 20-second *guess* was wrong, and that it transpired ultimately that the 5-second exposure was correct, what then? The over-exposed 80-second image would be timed and its early appearance would undoubtedly lead to a shortened time of development detrimental to the 5-second image. *The answer is that such a trial print is a bad one.* It is useful to show that the correct exposure is more nearly 5 seconds than 80 seconds, but it does not give sufficiently exact information to lead at once to the making of a final print. Nevertheless, it gives information sufficiently exact to lead to the making of another trial print in which the correct exposure is somewhere in the middle of the series of exposures chosen.

Having found that the exposure is somewhere about 5 seconds, a second trial print can be given 2 seconds, 4 seconds and 8 seconds' exposure in strips, and it will be found that the time of appearance of the 8-second image is so little different to the appearance of the image in the case of the correctly exposed strip, that the error is negligible. It has already been suggested that a little experience will enable the photographer to make trial prints containing three exposures only instead of the wide 5 exposure trial print which a beginner is recommended to use. This experience, plus the determination to make a very defective trial print merely an introduction to another trial print, will eliminate the error due to timing a grossly over-exposed strip and applying to the whole print the time of development so calculated.

This matter would not have merited the space devoted to it had not this criticism been the favourite one of

those photographers who will see no good in the factorial method of developing prints. It is a matter of interest to note, however, that this criticism rarely comes from those who have given factorial development a thorough trial, but usually emanates from arm-chair critics.

It may appear to some that if an over-exposed image makes its appearance too soon, so that a total time of development which is too short results, the shortening of development may be so great that the print will fail to grow too dark, and show by so doing that it is over-exposed. This fear is groundless. No degree of over-exposure short of reversal will allow of development to the Watkins factors already given without yielding a print which is too dark. Conversely, no degree of under-exposure when developed to the same Watkins factors can be made to yield a print of the right depth, but will always lead to a print which is too light, in spite of the lengthened total time of development due to a delayed first appearance of the image.

The only exposure which yields the correct depth (darkness) of print when developed to an appropriate Watkins factor is the correct one.

Finally, it may be remarked that, granted though it be that a small error in timing the first appearance of the image in conjunction with another error due to timing an over-exposed portion of a trial print, may result in a print which is actually developed to a lower factor than 10 with Amidol or 5 with M.-Q., these Watkins factors have been chosen purposely because they are greater than the minimum factor allowable. It has already been stated that 8 is the minimum factor for Amidol and 4 for M.-Q. The purpose of the choice of 10 and 5 respectively is now apparent. If, with the intent to develop to a Watkins' factor of 10, mistakes lead to the use of a real factor of 8, no harm results, and the full quality indicative of adequate development is assured. It is only by gross carelessness that mistakes become such that a factor lower than 8 materialises when the factor of 10 has been intended.

There is, however, a real objection to factorial development which is seldom ventilated, but which deserves brief reference. The complicated events which take place between the application of the developer and the first appearance of the image, are different in nature from those which take place subsequently until development is completed. The claim of accuracy for factorial methods presupposes that the first series of events does not alter in the time of accomplishment without an equivalent time alteration in the second series of events. An analogy may be helpful. A suburbanite who goes to town daily may have to walk every morning from his house to the station and catch a train. Let it be assumed that the whole journey is accomplished day after day with unusual regularity, so that exactly five minutes is spent in the walk to the station, exactly 20 minutes is spent in the train and there is never delay between the termination of the walk and the departure of the train. The whole journey of 25 minutes' duration takes exactly five times as long as the walk which constitutes the first part of it. The Watkins factor, as it were, is 5. A morning arrives, however, on which the traveller is late in leaving the house, leaving himself only two minutes in which to reach the station. By running, he succeeds. The train part of the journey is unaffected and takes the usual 20 minutes. The whole journey is therefore accomplished in 22 minutes, of which the first portion took 2 minutes, a Watkins factor of 11, so to speak. On another morning the walking time may be normal and the train time abnormal. The time of first appearance of the image is the time spent in walking to the station, and the remaining time of development is the train journey, two successive events which have so little in common that a variation in the time of one may not be followed by a proportionate variation in the time of the other. This is the strong *theoretical* objection to factorial development and to any system of timing a complex operation from indications which

arise during an early and comparatively small portion of it. So far as developing-out papers are concerned this theoretical objection does not appear to be of any practical moment. A very long experience of factorial methods has failed to bring to the notice of the writer an undoubted example in which a developing-out paper has failed to respond to factorial development and reach the full quality of print which the negative will allow. If these occasions do arise they must be extremely rare.

In practical print production factorial development is successful, and it is the only method which allows the expert to convey to the beginner precise information concerning both the exposure and the development of a developing-out paper.

A Few Stories

It may not be out of place at this juncture to tell a few stories which serve to show what a valuable aid to exact work on bromide paper and chloro-bromide paper a factorial method of development can be.

On one occasion the writer was making an enlargement on bromide paper. A trial print was made and developed factorially and the appropriate exposure was chosen. This exposure was given to the final print, and upon development (factorially), the latter proved to be far too light, much lighter than the strip of the trial print chosen for imitation. Another trial print was made, and it transpired that double the exposure previously given was necessary. So exposed, a final print proved to be satisfactory. What was the explanation? Had the factorial system broken down? Was the real objection to factorial development, already described, operative? A telephone enquiry to the local electric power station brought forth the information that between the making of the first trial print and the first "final" print, a dynamo had broken down, resulting in a temporary loss of voltage. The light in the enlarging lantern had decreased in brightness without detection. Once more the teaching was true, namely, that

prints developed factorially are under-exposed when they are not dark enough.

It has been my privilege to lecture occasionally to various photographic societies on the subject of factorial development. It has been the practice to purchase fresh bromide paper the day before a lecture and make a trial print from a chosen negative, exposing to an electric filament lamp at a measured distance. On the evening of the lecture the same paper and negative and the same lamp and printing distance were employed. It was rarely the case that the exposure was the same. A trial print (developed factorially) showed exactly what was the difference. There could be one reason only, namely, that the current voltage was different from that of my home district. It was possible to tell the audience with certainty whether the current voltage in their lecture hall was above or below that of my house, and on no occasion has there been a mistake.

There are several makers of bromide paper who place upon the market two or three grades of paper which they claim will yield different degrees of contrast when printed from the same negative. Their utility is obvious, inasmuch as it is very convenient to have a soft (long exposure scale) bromide paper for negatives of high contrast, and a hard (short exposure scale) bromide paper for printing from negatives which possesses a low degree of contrast. It is a convenience similar to that which is experienced by those who, printing on gaslight paper, possess stocks of both the vigorous (short exposure scale) and soft (long exposure scale) varieties. In many cases the differences between bromide papers which purport to be different are real, but in other cases at one time they were not. The writer has in mind two bromide papers of a few years ago for which the makers claimed different contrast effects. Developed factorially these papers gave identical results when printed from the same negative. Upon analysis of the exposure and development data for the so-called " contrasty " paper and the so-called " soft " paper, it was found that the

former was a very slow paper so far as exposure was concerned, but developed very quickly, whereas the latter, the soft paper, was the very reverse, being extremely sensitive to light, required a brief printing exposure only, and was slow to develop. The photographer who did not know these exposure and development differences, and who developed by inspection, over-exposed and under-developed the alleged soft paper and under-exposed and fully developed the supposed hard paper. The result of over-exposure and under-development was flatness (together with a loss of quality in the print which made it amazing that the paper had any chance of continued existence), whereas the fully developed paper was able to exhibit good contrast. Factorial development showed the absence of a *real* contrast difference at once. The fact, however, that these two papers gained and maintained for some time a reputation for being all that they ought to have been, shows how singularly futile was development by inspection to detect the erroneous description. Photographers have the means of differentiating between true and false contrast differences at their disposal. It is only fair to add that the papers made by firms of repute which are advertised as "hard" and "soft," do in fact exhibit the contrast differences indicated by their description. This is one of many reasons which make it imperative to use printing papers made by the famous makers whose reputation is built up on the fine quality of their products.

It is not without good reason, therefore, that the writer ventures to claim that system and rule have their place in the exposure and development of the developing-out papers now under consideration. It may be that systems of development will eventually be devised which are better than the time rule already given for gaslight papers and the factorial rules given for bromide and chloro-bromide papers. But there can be no shadow of doubt that any system based on the known properties of developing-out papers is better than the futile methods

employed almost universally, namely, that of attempting to judge when the development of a print is properly completed by watching it.

Developer Differences and Variations

Before leaving the subject of development, it may be helpful to add a few remarks upon the differences that exist between the developing formulæ advocated by one paper maker and those recommended by another. The simple plan adopted by most writers of text books is to recommend photographers "to follow the paper makers' instructions implicitly." This recommendation is a sound one and free from risk, inasmuch as it shifts all responsibility from the writers on to the broad shoulders of the manufacturers. There are occasions when this is very fortunate. There is not, however, any evidence that each of the formulæ given above, when used for its own specific purpose, fails to do all that the innumerable formulæ of different paper makers can accomplish. Provided that they are well balanced and properly compounded and do not differ too much from a certain mean, the same developing agents and their adjuncts made up in solution in different proportions, differ in their effect in one respect only, namely, the length of time which they require in which to do their work. If the precaution be taken of ascertaining the working rate of each of several formulæ, and each be allowed to act for a time which conforms with that working rate, identical results accrue with rare exceptions. The writer can state with confidence that there is nothing lost to photographers through adopting the formulæ already given, if they are so inclined, in preference to other formulæ given in the instruction leaflets of various paper makers, and the great advantage will accrue that not only is exact information available concerning their working rate for various purposes, but the adoption saves the photographer, whose taste in papers is catholic, the necessity of compounding a host of developing solutions for use as occasion arises.

It is perhaps in regard to chloro-bromide papers and developing formulæ suitable therefor that these statements will be received with the greatest scepticism. It is very evident that a change in the constitution of the developer leads to a print of a different colour, *when the time of development is left unaltered.* But precisely the same change in colour of the print can be obtained by using an unchanged developer and altering the time of development (or Watkins factor). It seems fairly certain that the attainment of a desired colour is largely, if not entirely, a matter of adjusting the exposure and the time of development (Watkins factor), and the precise developer composition is a secondary and unimportant matter. The change colour effect arising out of the use of a special developing formula is attributable to the different rate at which the special developer works in comparison with the standard mixture, leading, unwittingly, to a real alteration in the degree to which development is carried. It is more simple and more under control to effect any colour change desired by manœuvring with the degree (time) to which development is carried with a normal unaltered developing mixture. It has already been noted that long exposure and short development give rise to warm colours, and shorter exposure and longer development yield silver deposits of a colder colour. This control is both simple and efficient, and all that is required.

It will now be evident that in print making, as in negative making, time is the all-important factor. The time of exposure must be right and so must the time of development. Little else matters. If, from a suitable negative, bad prints result, one or other, or both, of these times are at fault. It simplifies matters enormously for beginners, and for those struggling against adversity, to bear that truism in mind. There is no need to seek for obscure causes of failure until it is certain that the fault does not lie in an exposure error or a time of development error. There should be no difficulty in avoiding gross errors in these two directions if the simple

rules already described are followed. There are indeed very few operations in practical photography which do not depend for their success upon the choice of an appropriate reaction time.

Chapter V.

THE FIXATION, WASHING, AND DRYING OF PRINTS

WHEN the development of a print has been completed, it remains necessary to remove the unexposed and undeveloped silver salt by means of a solution of hypo,* a process known as fixation. It is very desirable to use a solution of hypo which has been made acid by the introduction of other chemical bodies rather than use a plain solution, for by so doing not only is development arrested immediately, but the risk of stain on the print is minimised very considerably.

Appropriate formulæ for acid-hypo solutions are as follows :—

Acid Hypo Bath.

	English	Metric
Sodium Hyposulphite (hypo) .	1 pound	200 grammes
Potassium Metabisulphite .	2 ounces	25 ,,
Water to	80 ,,	1,000 c.cs.

An alternative acid hypo bath, which is cheaper, yet equally efficacious, is given below :—

Acid Hypo Bath.

	English	Metric
Sodium Hyposulphite (hypo) .	1 pound	200 grammes
Stock Acid Solution . .	8 ounces	100 c.cs.
Water to	80 ,,	1,000 c.cs.

Dissolve the hypo in water, and, when solution is complete, add the stock acid solution.

The stock and acid solution is made up as follows :—

Stock Acid Solution.

	English	Metric
Sodium Sulphite (cryst.) .	4 ounces	100 grammes
[or Sodium Sulphite (anhydrous)	2 ,,	50 ,,]
Glacial Acetic Acid . .	3 ,,	75 c.cs.
Water to	40 ,,	1,000 c.cs.

* Sodium Thiosulphate, popularly known both as Sodium Hyposulphite and as Hypo.

The sodium sulphite must be completely dissolved in water in the first place, and the acid is then added *a few drops at a time with constant stirring* of the sulphite solution.

Those photographers who prefer to make use of a combined acid fixing and film hardening bath can use the following solution :—

ACID HYPO HARDENING BATH.

	English	Metric
Sodium Hyposulphite (hypo) .	1 pound	200 grammes
Stock Acid Hardener . .	8 ounces	100 c.cs.
Water to	80 ,,	1,000 c.cs.

Dissolve the hypo in water, and, when solution is complete, add the stock acid hardening solution.

The stock acid hardener is made up as follows:—

STOCK ACID HARDENER.

	English	Metric
Sodium sulphite (cryst.) .	4 ounces	100 grammes
[or Sodium Sulphite (anhydrous)	2 ,,	50 ,,]
Glacial Acetic Acid . .	3 ,,	75 c.cs.
Potash Alum . . .	4 ,,	100 grammes
Water to	40 ,,	1,000 c.cs.

In making up this stock solution the following directions must be followed exactly. Dissolve the sodium sulphite in 10 ounces (250 c.cs.) of *cold* water, and, when solution is complete, add the acetic acid little by little, stirring the sulphite solution all the time. Dissolve the alum in 20 ounces (500 c.cs.) of *hot* water in another vessel. When dissolved, cool the alum solution *thoroughly* and add it to the Sulphite-Acetic Acid mixture. Add cold water to make up the bulk to 40 ounces (1,000 c.cs.).

Under no circumstances must the mixture of these two solutions be made until the alum solution has been cooled below 70° *F.*

Into one or other of these fixing solutions the developed print is plunged after having been given a brief rinse in water.

How long does it take to " fix " a print completely ? In the case of negatives the unchanged silver salt can be seen to disappear as it passes into solution, and by inspection alone it can be judged when fixation is complete. The completion of fixation of paper prints is a very much more difficult matter to judge, for the following reasons :—

(1) The tendency of prints to collect together and lie in a mass in the fixing bath.

(2) The absence of any visible sign that the unchanged silver salt has been completely dissolved.

It is imperative that prints, when fixing, should be prevented from lying one on top of another.* It is impossible for fresh hypo to diffuse into the middle of a collection of adherent prints and for silver-charged hypo to diffuse out. The chief aid to proper print separation is the use of a large dish as a container for the fixing bath. Twenty ounces of one of the hypo solutions given above in a dish 10 inches by 8 inches yields a depth of solution of a little over 1 inch. In such a dish eight or nine $\frac{1}{4}$-plate prints will float freely and can be kept separate from one another, and there is ample depth of hypo to cover them. This size of dish for fixation purposes should be regarded as the minimum. If a larger dish be used, a correspondingly greater quantity of hypo solution should be placed therein. The practice of placing a number of $\frac{1}{4}$-plate prints one on top of another in a $\frac{1}{4}$-plate dish full of hypo solution invariably leads to incomplete fixation and its attendant troubles.

Twenty ounces of one of the fixing solutions given above will completely fix 1,500 square inches of print surface, equivalent to 100 prints of $\frac{1}{4}$-plate size, 75 prints measuring 5″ 4″ or post card size, 50 $\frac{1}{2}$-plate prints, or 25 whole-plate prints. This is the limit to which the fixing bath should be used. Free access of

* It is almost invariable that several prints are in a fixing bath at the same time and it is highly inconvenient to fix one print at a time only.

the hypo to every print, as indicated in the previous paragraphs, is assumed.

It materially helps complete fixation to run two hypo baths at the same time, No. 1 and No. 2. Apart from the fact that it allows a greater number of prints to be fixing at any one time without undue crowding, it permits of an arrangement where by the terminal portion of the fixing process takes place in the fresher and less-used bath.

When development is complete and a brief rinse in water has been given, the print is plunged into the No. 1 bath. For a few moments it is kept in a state of agitation so that the developer is washed out of the print as quickly as possible. It is then separated from other prints with the help of a print paddle and allowed to lie in the bath for 5 minutes. At the end of that time it is transferred to bath No. 2, and allowed to remain there for another five minutes, again taking the precaution of separating it from other prints with the aid of a print paddle. Fixation is then complete, and it is ready for washing.

A twenty-ounce No. 1 bath should be thrown away when 1,500 square inches of print surface (see above) have passed through it. It is then replaced by the No. 2 bath, which thus becomes No. 1, and a *fresh* No. 2 bath is put into commission. The chief work falls upon the No. 1 bath, and the comparatively fresh No. 2 bath is able to complete fixation with ease and certainty.

It is an aid to stain-free prints to make it an invariable practice to immerse prints in the hypo *face downwards* and not face upwards. Prints which are allowed to float face upwards on the surface of the hypo will stain or patchy reduction of the silver image will result. The agitation of the print for the first few moments after its immersion is an aid to the prevention of stain.

A print paddle is a necessity. This contrivance, made in vulcanite, and possessing either a ringed or flat foot can be obtained cheaply. Its use avoids any

necessity for dipping the fingers into the hypo bath and running the risk of conveying this material, with disastrous results, into the developer, or on to the sensitive surface of the paper which is being handled prior to development. A ringed print paddle can be so manipulated that it can be made to carry a print from one fixing bath to another, or from the latter to the washing water. The hands need not, and should never, come into contact with the hypo solution during the progress of any photographic operations.

There is a common practice which photographers are advised to guard against. It is very tempting, when a long succession of prints are being developed one after another, to dump them into the fixing solution and leave them there until the fixing bath appears to be overcrowded, and then transfer them all at once to the wash water to make room for fresh prints. This will not do. The prints which were first developed will be left in the hypo too long and the prints which were developed last will remain therein for too short a time. Immersion for too long a time may lead to some loss of delicate high-light detail, and too short a time obviously risks incomplete fixation. There should be a regular and even procession of prints from one bath to another at definite time intervals. If development is being conducted so rapidly that prints are choking up the fixing bath, obviously a larger fixing bath must be used, or there must be a pause in development. It is an aid to the recognition of the order in which prints should be transferred from one fixing bath to the other and thence to the washing water if they are numbered on the back in pencil before exposure. There is no harm in allowing a number of prints to accumulate in a bowl of water, after transfer from the second fixing bath, preparatory to the next operation to be described, namely, washing.

It should be remembered that the area of print surface which a given quantity of hypo will fix (see above) is a maximum that is only efficient when proper

attention is paid to the fixation process. Hypo is cheap and paper is dear. If there is any doubt as to the efficiency of a used hypo bath it should be discarded forthwith or put under test. A simple test of efficiency is a comparison of its power of dissolving the silver salt from a strip of *unexposed* plate with that of a fresh solution applied to a strip of the same plate. If it takes twice as long to clear the plate with the used hypo as it does with fresh, the bath has exceeded its useful life, and should be discarded. Any discolouration of the No. 1 hypo bath due to excess of developer being carried into it by successive prints, should lead to its condemnation.

There is one after-process applicable to prints on developing-out papers which depends for its success on a much higher standard of complete fixation than that already described, namely, sulphide toning by the two-bath process, involving bleaching the print in a solution of potassium ferricyanide and a soluble bromide and toning it in a solution of soluble sulphide. Prints which have been fixed in a hypo bath containing more than 2.5 grammes of dissolved silver salt (from other prints) per litre, will suffer from degraded whites when subsequently sulphide toned.* A twenty-ounce hypo bath will contain this amount of silver salt after the passage through it of 120 square inches of print, equivalent to eight $\frac{1}{4}$-plate size pieces of paper. It is imperative that, for prints destined for sulphide toning by the two-solution process, the No. 2 hypo bath shall be either quite fresh or shall not have "fixed" more than that area of printing paper. Hypo is cheap enough to make it worth while using a clean fresh No. 2 bath for this purpose. Provided that the No. 2 bath is up to standard it does not matter if the No. 1 bath is below this standard. This difficulty of degraded whites in toned prints attributable to a hypo bath containing more than a certain amount of silver, does not arise in toning in a hot hypo-alum bath or with liver of

* Lumière and Seyewetz, *British Journal of Photography*, November 30, 1923.

sulphur, provided that the latter is used in a solution not less than 10% in strength.

Washing Prints

The conditions readily fulfilled for the purpose of removing hypo rapidly and completely from negatives * cannot be applied with the same success to prints, for the following reasons :—

(*a*) Prints in running or agitated water tend to collect together in a bunch.

(*b*) It takes very much longer, and is more difficult for hypo to diffuse out of both a gelatine film and a paper base than it does out of the gelatine film of a plate.

The washing rule for thick papers (and post-cards) is that each print shall be soaked for 10 minutes in 12 complete changes of water. The washing rule for thin papers is that each print shall be soaked for five minutes in 12 complete changes of water.

In both cases it is assumed that the prints are not allowed to collect together in a mass, but that each print is allowed free access of water to both the paper back and the gelatine front.

The practice of placing a number of prints in a bowl or a dish and allowing water to run in continuously from a tap is useless. The prints are washed into an adherent mass and the water change efficiency is doubtful. The same criticism applies to the great majority of mechanical washers. The washing of a number of prints at the same time is an extremely difficult and tedious business, but, nevertheless, unless it is done efficiently, the disastrous effects of insufficient washing will, sooner or later, become evident. A simple scheme, although requiring a good deal of attention, is to procure a large white porcelain photographic dish measuring about 20″ × 16″ and provided with sides at

* "The NP." Handbooks, No. 1 (second edition), Chapter VII.

least 2½″ deep. Into this dish is fitted a wooden frame 1″ deep, of such dimensions that it will lie on the floor of the dish and touch its walls. The frame is suitably weighted with lead. Across the frame is stretched and attached a piece of butter muslin. The dish is filled with water to a depth of at least 2″, and on the muslin are laid the prints to be washed, placed so that they do not overlap. At the end of every 10 minutes (thick papers) or 5 minutes (thin papers), the frame and the prints thereon is removed, the water completely changed and the prints are replaced. Above and below each print is 1″ of water, into which the hypo diffuses readily. It is to be feared, however, that the washing of prints is usually scamped. The standard of washing laid down should be regarded as an ideal one at which to aim if possible.

Drying Prints

Washing completed, the prints are ready for drying. It facilitates the rapidity with which drying takes place if, on removal from the wash water, they are laid on a clean towel placed on a hard flat surface and over them is spread another towel. The two towels with the prints between them are stroked together with hand pressure, and all surface water adhering to the prints is thereby removed. Drying can be completed by placing the prints face upwards on another towel in a warm dust-free place. A hot-water cylinder cupboard is an admirable drying place. Blotting the prints between towels will neither hurt the materials of which towels are made nor will it damage the prints.

The completion of the drying operation brings us to the end of the technical procedure which relates to the production of a perfect print. It is not proposed to make any reference to trimming and mounting, etc., after-processes which are necessary if a perfect print is to stand a proper chance of displaying its pictorial qualities. It will perhaps be recognised that a print may exhibit perfect technique without possessing

any claim whatever to pictorial merit. It is not equally true that faulty photographic technique totally condemns the pictorial attributes of a photograph, but it cannot be controverted that that happy combination of perfect technique and pictorial quality makes an irresistible appeal to those capable of recognising that pure photography can be made a marvellous means of pictorial expression.

Chapter VI.

MISCELLANEOUS MATTERS

ENLARGEMENTS can be made on any of the papers already dealt with, using either daylight or artificial light as an illuminant for the negative. When daylight is used in conjunction with a daylight enlarging apparatus, there is a tendency to over-expose bromide papers through using a printing light of such a high power with a paper so very sensitive to light. With artificial light as an illuminant, the exposure, when enlarging on to a slow gaslight paper or a slow chloro-bromide paper, may run into many minutes unless a powerful light of 200-400 candle-power is used, together with a condenser between the light and the negative. The new condenserless vertical enlargers suffer from the disability that they require an extremely powerful light to enable them to yield enlargements on slow papers in a reasonable length of time.

The technical procedure relating to the exposure and development of a print made by enlargement is identical with that already laid down for contact prints. Exposure is estimated by trial and development conducted by rule. When using an artificial light enlarger, the bromide or other paper is pinned on an easel and can readily be covered* up by a card, strip by strip during exposure, in order to yield a trial print containing several exposures which, upon development, denote by their appearance which one is the most appropriate. When using a daylight enlarger, however, it is impossible to cover up the paper strip by strip,† but exactly the same result is arrived at by covering up the negative from which the enlargement is being made.

* Note that the paper should be *covered* up bit by bit and not *uncovered* in the same manner. See footnote to page 24.

† Except in those types in which the paper is held in a dark slide provided with a draw shutter.

The series of exposures which should be given is the same as that already described under contact printing, namely, one in which each successive exposure is double the one before it. It is real economy to make a trial print on a piece of paper which is the full size of the enlargement. A small piece of paper will not often include within its boundaries an area of picture of which the tones are representative of all the important picture tones. The man who can, without fail, make twelve good prints out of a packet of twelve sheets of paper has not yet been born. It is an aid to six good prints if six of the sheets of paper are made to serve the purposes of trials.

In like manner, the development of an enlargement is in no way different to that appropriate for a contact print on the same paper. When enlarged prints are very large, the advantage of soaking the paper in clean water (of the room temperature) before applying the developer will be even more apparent than it is when dealing with smaller prints. Care must be taken to devote sufficient developer to a very large print. Appropriate quantities for different print sizes have already been given.* Used once, these quantities of developer should be discarded.

More care should be taken than is usually the case to prevent stray light escaping from an enlarging lantern and fogging the printing paper during exposure. Those lanterns which utilise an incandescent electric lamp ($\frac{1}{2}$-watt or vacuum type) can be made light-tight by stopping up every ventilation hole with black paper or in some other way. When the illuminant is an oil flame or gas or an electric arc, although excessive ventilation can be avoided some air inlets and outlets must be left. These should be situated on the side of the lantern furthest from the sensitive paper, so that any light escaping does not strike directly on to the printing paper. It is an additional aid to fog-free prints from this cause if a black screen about the same size as the

* Chapter IV.

enlarging easel be placed in front of the lens, through a hole in the centre of which the lens peeps. Over this screen and the enlarging easel can be thrown, and securely pinned, a black cloth. On the enlarging bench between the screen and the foot of the easel there should be spread a piece of black paper or cloth. In this way printing is being conducted in what is virtually a black box. A sheet of white paper left lying on the enlarging table at the foot of the enlarging easel, may reflect stray light on to the "enlargement" and result in pronounced general fog. Another unsuspected cause of fog, etc., on occasion, is an unsafe orange cap on the lens of the enlarger. The use of powerful illuminants, large aperture lenses and fast bromide paper make this danger very probable. It is not necessary to have a very strong image projected through the orange cap on to the easel to enable the printing paper to be pinned in the right position. It is advisable to cover up most of the orange-coloured glass with black paper, leaving in the centre a round hole about the same size as the F/11 stop in the lens. The margin of safety is thereby greatly increased and the operation of pinning up the paper may be conducted in a more leisurely and comfortable manner.

With these precautions an enlargement should be as clean and fog-free as a contact print made under the same development conditions. It is true comment that prints made by enlargement seldom do reach the fog-free standard that they should.

Dark Room Illumination

Nothing adds to the comfort and efficiency of printing on developing-out papers more than the possession and use of a satisfactory dark-room lamp fitted with an efficient "safe-light." Screens made of yellow or orange fabric, or those consisting of yellow or orange glass, are not safe when they yield sufficient light for comfortable working, and they yield no light worth speaking of when their safety factor is raised sufficiently

to allow of the unhurried manipulation of a fast bromide paper. Safe-lights which consist of dyed gelatine films mounted between glass sheets are now obtainable from several makers. The Wratten Safe-lights were, I believe, the first to be introduced, and they are famous for their efficiency. They are designed for use with *indirect* lighting, and their safety is lowered if *direct* lighting be employed. The same observation is true of all safe-lights. A very useful size is 10″ × 8″. Of the Wratten Safe-lights, the Series "I" variety is of all-round utility, being suitable for working with the fastest bromide papers and all sensitive materials of lower speed, such as slow bromide papers, chloro-bromide and gaslight papers, and lantern plates. A brighter light is given by the Series "O" Safe-light and, with care, it can be used when manipulating fast bromide paper. The latter safe-light is quite suitable for use when manipulating the other slower sensitive materials enumerated above.

The name safe-light is a somewhat misleading one. These screens do not yield a light which is safe for an indefinite period. Their safety factor is high, certainly, in comparison with screens made of orange fabric or orange glass, but they are not fool proof. The danger period with all sensitive materials is while they are dry. As soon as they become wet by plunging them in water or in the developer, their sensitiveness begins to fall and, shortly after development has passed the early stages, it has fallen very much. The obvious deduction is that a much brighter dark-room light can be used with safety if care is taken to protect the paper from direct light action whilst printing frames are being loaded and unloaded. These two operations can easily be conducted with the back to the dark-room light so that the paper, when in its most sensitive state, is protected by the shade of the body. The practice of leaving a packet of paper open on the table in the light of the lamp while the printing frame is being loaded with one sheet, is sure to lead to light fog. The paper

stock should be covered up, either in its original wrapping or in a light-tight box, as soon as the required sheet has been extracted. These precautions are even more important when an inefficient dark-room light is in use.

Safe-lights are not absolutely safe but only relatively so. This safety factor can be lowered in three ways, namely :—

(*a*) The use of a light directly behind the safe-light screen, or the use of indirect lighting which is more powerful than that for which the screen is designed.

(*b*) Too short a working distance.

(*c*) Too large an area of safe-light in relationship to the working distance.

The Wratten Safe-lights, and others like them, are designed for use with indirect light from a 16 candle-power lamp. The indirect lighting effect is secured by placing the lamp in a separate lamp chamber and reflecting its rays on to the safe-light by means of a white reflector angled at 45° with the safe-light. If direct lighting is used by placing the light immediately behind the safe-light, or if a more powerful lamp be used to provide indirect lighting, the safety of the screen is reduced.

The working distance is of importance. The nearer to the lamp the sensitive material is displayed, the shorter is the time which elapses before a fogging effect takes place. A method of checking the efficiency of the working distance is given in a later paragraph. The area of the illuminated safe-light in relationship to the working distance is also a matter of importance. It is commonly thought that because the light is called safe, an indefinite increase in area is permissible without lowering the safety factor. This erroneous idea appears to be based on the assumption that all the light rays to which papers or other sensitive material are sensitive, are removed by the screen, and only those rays allowed to pass to which the sensitive materials are insensitive. This is not so. The filter transmission is not sharply cut, nor is the sensitive paper only sensitive to some rays

of light and not sensitive to others. Given time, fast developing-out papers will fog in any light which is visible, and given time they will fog in the bright light transmitted by a safe-light. If, with a safe-light of a certain area, fast bromide paper is safe for 2 minutes at a distance of 6 feet, a safe-light of double the area will reduce the safety limit to 1 minute (approximately) at the same distance, a safety limit which could be restored to 2 minutes, if necessary, by working further from the light.* An increase in safe-light area has this advantage, however, namely, that the general illumination of the room is greatly benefited and the comfort and convenience of the worker thereby increased. If with the general increase in illumination a proper working distance be chosen, there is nothing but gain from using a large safe-light instead of a small one.

The writer's dark-room lamp is attached to the wall, so that the bottom of it is 6 feet from the ground. A safe-light, $10'' \times 8''$, illuminates the whole room so well that small print can be read easily. The minimum working distance is 4 feet and no sensitive material is approached nearer to the lamp except during the few seconds necessary to make sure when the image is appearing, a lapse from virtue productive of no harm when other operations such as loading the printing frame and so on, which could perfectly well be done in the dark, have been conducted in the manner that they should be, namely, as far away from the dark-room lamp as may be convenient and in the shade of the body. Nevertheless, these data concerning lamp and working distance are of no value to others because the safety factor is influenced by room size, room colour† and the manipulative peculiarities (speed of working, etc.) of which every individual photographer has his own. Every photo-

* In the example chosen a new working distance of 9 or 10 feet would equalise matters.

† Covering the dark-room with white paper in place of a coloured one, and in this way raising the value of the general illumination, results in a lowered safety factor identical with that produced by increasing the illumination in any other way.

grapher can test the matter for himself in the following simple manner. The standard to which to work is that the whites of a print should, if required, be of the whiteness of the same printing paper which has been fixed in hypo without either exposure or development. A print is made under the exact working conditions the photographer intends to employ on all occasions. A portion of the print is protected from the exposing light by placing a piece of black paper between the negative and the paper during printing. So exposed, the print is developed and fixed. The white strip protected by the black paper should compare favourably with the whiteness of unexposed, undeveloped and fixed paper of the same variety. Fog indicates the desirability of an increase in the working distance. Continued fog, in spite of an increase in working distance and every precaution suggested in previous paragraphs, throw suspicion on to the developer. The fault can be attributed to the developer if all operations are conducted in the dark (developing by time in a covered dish) and fog is still produced. Stale chemicals, an improper formula, or a wrong method of compounding the developer should then be the subject of investigation. The very last thing to suspect, unless fog makes its appearance under conditions hitherto fog-free, is faulty paper. A manufacturer of developing-out papers is incomparably superior to the average photographer in care and attention to detail, and it is a thousand to one that faults lie at the door of the latter and are not due to errors of the former.

The Right Side of the Paper

Difficulty is sometimes experienced in detecting upon which side of the paper the emulsion is coated. This difficulty does not exist in the case of glossy or semi-glossy papers, as the emulsion side shines and the non-emulsion side is matte. In the case of matte papers, however, the two sides are sometimes so much alike that difficulty may arise. It is unwise and unnecessary

to take the doubtful sheet very near to the dark-room lamp for careful scrutiny. The following suggestions may prove helpful :—

(*a*) Make yourself familiar with the manner in which the manufacturer packs his paper. The usual way is to place all the sheets facing one way (say emulsion to the right) except one sheet at the end of the pile of paper of which the emulsion faces the reverse direction and so protects from contact with the packing paper, the emulsion on the next sheet to the left. Familiarity with the method of packing can lead to the removal of a sheet, of which the emulsion side is known, without inspection. It is a useful tip, when papers are packed in the manner described, to remove sheets for use from those of which the emulsion is facing the same way and leave to the last the one sheet of which the emulsion is facing the reverse way, so that its protective influence is exerted to the end.

(*b*) Gelatine coated paper tends to curl emulsion side inwards. In the case of thin paper this is invariably so. In some thick papers the writer has occasionally met with a curl in the opposite direction.

(*c*) If the corner of a gelatine coated paper be taken between the teeth and bitten hard, the emulsion side will stick to the teeth more firmly than the paper side.

Observation in one or other of these directions should render it unnecessary to indulge in the dangerous practice of gazing at the printing paper in the strong light of a closely approached dark-room lamp.

Timing

It has already been stated that appropriate timing is the basis of successful photography. An appropriate time for any purpose having been chosen, it remains

essential to take steps to make sure that the chosen time is employed with reasonable accuracy and a minimum of inconvenience.

There are two methods of timing the dark-room operations of print exposure and print development, namely :—

(*a*) With the help of vision.

(*b*) With the help of sound.

The former method with the aid of a watch or a clock is the common one. It is inconvenient and can be inaccurate. It is impossible to watch two operations carefully and with accuracy at the same time. It is very trying to have to pour developer over a print in a shallow dish and at the same time glance at the dial of a dark-room clock or the small seconds hand of a watch. It is possible, but not easy, to time the first appearance of an image with one eye on the print and the other on a watch or clock. Let the eyes be devoted entirely to watching the photographic part of the game and devote the ears to timing. They have no other useful photographic function, and can devote their whole time and attention to it. Those who possess a metronome have a sound timing apparatus at their disposal which requires no elaboration. Adjust it to beat half-seconds and count every other beat for periods to be timed in seconds. Those who do not possess a metronome can make a perfectly efficient sound-timing device out of a *pendulum* clock. A suitable clock, worked by a suspended weight, can be bought as cheaply as half-a-crown. Remove the existing pendulum and hang in its place a piece of copper wire* (gauge 12) so that the total length of the pendulum from the axis of the escapement to the lower end is $14\frac{1}{2}$ inches. Such a pendulum will tick half-seconds. Every other tick indicates the passage of one second. Start any timing operation by saying "nought" coincident with any tick and the commencement of the operation being

* Obtainable from an ironmonger for about twopence per yard.

timed.* If the pendulum length given above results in seconds which are too brief, lengthen it. If the seconds are too long, shorten the pendulum. An accuracy to within one second in five minutes is readily obtainable from any clock which will go at all. The comfort and convenience of timing by sound has to be experienced to be realised. The writer has for years used no other method for timing ordinary photographic operations, so that it has become, in his case, almost subconscious, allows other things to be done at the same time without confusion, and leaves the eyes disengaged for other important purposes. It is as well to remember that the alteration in pendulum length renders inaccurate the lapse of time indicated by the clock hands.

[FINIS].

* When timing any operation in seconds or any other unit of time, the first word to be said or thought is *nought*, following by one, two, three, etc., and not *one*, followed by two, etc.

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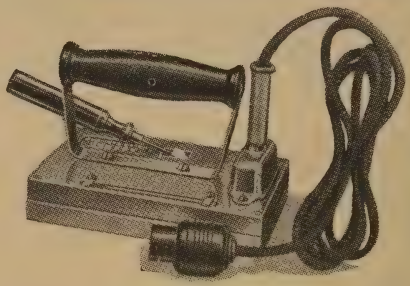

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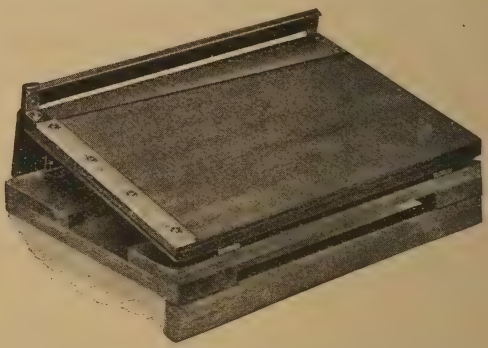

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